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The SCIENCE COUNSELOR

Volume VIII ★ Number 1 ★ March, 1942

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The Science Counselor

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National Science Essay Awards . . .

Duquesne University announces the following awards in its 1942 National Science Essay Contest:

FIRST PRIZE: Marita Bos, Marycliff High School, Spokane, Washington. Supervised by Sister M. Celine, F.S.P.A.

HONORABLE MENTIONS: All of equal merit.

Max Joseph Richard, Saint Bernard College High School, Saint Bernard, Alabama. Rev. Charles Reiner, O.S.B., Supervisor.

Margaret McDermott, Bishop McDonnell Memorial High School, Brooklyn, New York. Sister M. Thomas Aquin, O.P., Supervisor.

Thomas J. Donoher, Central Catholic High School, Toledo, Ohio. Sister Marie Therese, Supervisor.

Jean Sloan, Indian Lake, Ohio. School of the Brown County Ursulines, St. Martin, Ohio. Sister Miriam, Supervisor.

Winifred Ann McNamee, St. Rosalia High School, Pittsburgh, Pennsylvania. Sister M. Josephine, Supervisor.

To the winner of the first prize is given a gold medal for permanent possession; to the winner's school a suitably engraved silver cup for one year's possession.

In congratulating the winners the University expresses the hope that all who were concerned with the contest, either directly or indirectly, will be stimulated to greater interest and accomplishment in science.

The Performance of Science Teachers on the 1941 National Teacher Examinations

● By **Carl A. Pearson,** Science Editor, and
David G. Ryans, Executive Secretary,
COOPERATIVE TEST SERVICE, NEW YORK CITY.

National Teacher Examinations are a new and valuable means of measuring the knowledge and certain of the abilities of teachers, experienced and inexperienced. They are designed to help employers of teachers select the most promising candidates.

Sponsored by the American Council on Education, they are offered annually in a number of centers throughout the country. Some teachers take them to demonstrate their qualifications objectively on a national scale; others because an ever increasing number of school systems are requesting the examination records of those who seek employment in their systems.

All teachers will be glad to know of these examinations, their purpose and content, and how they are conducted. Our readers will be especially interested in the performance of the science teachers who were examined in 1941.

●

This article has been prepared with the object of presenting a brief analysis and comparison of the results on the National Teacher Examinations of candidates for teaching positions in the fields of biological and physical science.

The National Teacher Examinations

The *teacher,* as a guide of the learning process in school, exerts a singularly profound influence on the pupil and, perhaps more than any other factor, contributes to the effectiveness of educational efforts. The teacher's intellectual and cultural backgrounds are inevitably reflected in what a child learns. Both the teacher-educator and the employing superintendent accept as one of their chief responsibilities to society the selection and development of potentially successful teachers.

The National Teacher Examinations are intended for the objective measurement of certain of the teaching candidate's abilities and knowledge. They have been planned and prepared on the assumption that such qualities do contribute to teaching success and that they are capable of valid and reliable estimation.

The National Committee on Teacher Examinations was formed in 1939 by the American Council on Education in response to the suggestions of school teachers, superintendents, and teacher-educators throughout the country. It was authorized to supervise the task of preparing a battery of objective tests for the examination of teaching candidates which might aid school administrators in their efforts to improve the selection of new teachers and also provide prospective teachers with the opportunity to demonstrate their qualifications objectively on a national scale. Three editions of the National Teacher Examinations have been constructed and administered.[1] Completely new editions of the examinations are prepared each year.

The 1941 National Teacher Examinations were given in sixty-four official examining centers and ten subcenters. A total of 172 school systems cooperated in the 1941 program, the superintendents indicating their desire to receive examination records along with the other credentials of candidates who were applying for teaching positions in their systems.

The following examinations comprised the 1941 battery:

Common Examinations (recommended for all candidates on the theory that admission to the profession in any capacity should be restricted to those above a certain minimum of intelligence, culture, and professional preparation).

- Reasoning ..... 40 minutes
- English Comprehension ..... 40 minutes
- English Expression ..... 40 minutes
- General Culture ..... 180 minutes
  - Current Social Problems
  - History and Social Studies
  - Literature
  - Science
  - Fine Arts
  - Mathematics
- Professional Information ..... 120 minutes
  - Education and Social Policy
  - Child Development and Educational Psychology
  - Guidance, and Individual and Group Analysis
  - General Principles and Methods of Teaching
- Contemporary Affairs ..... 60 minutes

Optional Examinations (examinations to show mastery of the subject-matter to be taught). Candidates for elementary-school positions took number 1, and candidates for high-school positions any two others.

[1] The National Teacher Examinations were most recently administered on January 2-3, 1942. Since the scoring and analysis are now in progress, no report of these results is presently available. The examinations were previously administered in March, 1940, and March, 1941.

1. Education in the Elementary School ..... 120 minutes
2. English Language and Literature ..... 90 minutes
3. Social Studies ..... 90 minutes
4. Mathematics ..... 90 minutes
5. Biological Sciences ..... 90 minutes
6. Physical Sciences ..... 90 minutes
7. Spanish ..... 90 minutes
8. French ..... 90 minutes
9. German ..... 90 minutes
10. Latin ..... 90 minutes

A complete bibliography of publications concerning the National Teacher Examinations may be found at the end of this paper. Copies of most of these publications are available to interested persons and may be secured from the central offices of the National Committee on Teacher Examinations, 15 Amsterdam Avenue, New York, New York.

The Performance of Science Teachers

Of 4,718 candidates taking the National Teacher Examinations in March, 1941, 289 gave as their first teaching preference either the biological or the physical sciences. This group includes inexperienced prospective teachers as well as teachers with experience. A comparison of the performance of these science teachers with that of the entire group reveals some interesting facts.

The common examination scores of science candidates on tests covering nonverbal reasoning, English comprehension, English expression, general cultural information, professional information, and contemporary affairs are given in Table I.

It may be observed that the performance of prospective teachers of science on these examinations compares very favorably with that of other subject-matter groups.[5] As would be expected, the average scores of the two groups of prospective science teachers on the science section of the general culture test are both higher than that of any other group. The better-than-average performance of the science teachers on the reasoning test and on the mathematics section of the general culture test might also have been predicted. However, their relatively high scores in current social problems and contemporary affairs and their better-than-average performance in social studies and professional information cannot be explained on the basis of specialized academic training. English expression and literature are the weakest points in their background, and even here the biological sciences group is average. On the common examinations as a whole, the physical sciences group averages somewhat higher than the biological sciences group.

The optional examinations in the biological and physical sciences were formulated with the assistance of subject-matter experts in the subdivisions of each science. A tentative outline of objectives and subject-matter to be included in the tests, based on an analysis of textbooks and courses of study, was drawn up and submitted for criticism to a large number of teachers and supervisors. On the basis of their suggestions the outline was revised, and test items were written. These items were tried out experimentally, and only those retained that proved to be of appropriate difficulty and discriminatory power. These were put into a tentative form that was gone over by several critics and revised on the basis of their suggestions.

[5] The unit of comparison, the Scaled Score, is derived from the raw score, and is directly comparable from test to test. A Scaled Score of 50 represents the expected score of an *unselected* group of individuals if they had four years of college training or its equivalent. It should be pointed out that this does not mean that the average college graduate would receive a Scaled Score of 50 on these tests. He would receive a higher Scaled Score because the people who actually do complete four years of college are somewhat selected.

TABLE I

Average Scaled Scores on the common examinations classified according to type of position listed by candidates as their first teaching preference.

Type of Position	No. of Candidates*	*General Culture*												
		Reasoning	English Comp.	English Exp.	Current Soc. Prob.	Hist. and Soc. St.	Literature	Science	Fine Arts	Math.	Total	Prof. Inf.	Cont. Affairs	Com. Exam. Total
Elementary School Teacher	1287	59	63	59	59	57	59	56	59	57	348	61	58	595
English Teacher	542	59	71	68	63	62	72	58	66	60	382	65	64	648
Social Studies Teacher	490	58	68	59	67	69	63	59	62	59	379	66	70	641
Mathematics Teacher	260	70	66	63	63	62	58	66	58	81	388	67	64	658
Biological Science Teacher	**149**	**61**	**66**	**59**	**63**	**60**	**60**	**72**	**60**	**65**	**381**	**64**	**65**	**633**
Physical Science Teacher	**140**	**64**	**67**	**58**	**66**	**63**	**58**	**78**	**60**	**71**	**395**	**66**	**68**	**654**
Foreign Language Teacher	241	60	71	67	60	61	66	56	64	62	369	62	62	634
Commercial Teacher	218	60	64	62	63	60	58	55	58	59	353	63	64	615
Home Economics Teacher	129	58	60	54	57	52	55	57	58	52	331	58	56	567
Shop Teacher	126	60	61	49	60	57	51	64	56	62	350	55	64	574
Music Teacher	150	58	63	58	57	55	58	53	65	55	342	58	60	584
Art Teacher	132	64	65	59	59	57	61	57	71	56	361	60	60	609
Physical Education Teacher	212	58	59	51	57	53	53	57	54	54	328	56	60	560
Average (all teachers)	---	**60**	**65**	**59**	**61**	**60**	**60**	**58**	**60**	**59**	**362**	**63**	**61**	**616**

* Categories with a total number of cases fewer than 100 have not been reported.

The examination in the biological sciences, taken by 305 candidates as either first or second optional examination, was composed of 177 items. The subject-matter allotment was approximately as follows:

Botany 24 per cent, zoology (excluding human beings) 28 per cent, human anatomy and physiology 29 per cent, historical geology and evolution 4 per cent, general 9 per cent, and teaching methods 6 per cent. The examination in physical sciences, taken by 292 candidates, was composed of 105 items divided roughly as follows: physics 40 per cent, chemistry 40 per cent, earth science (geology and meteorology) 16 per cent, and astronomy 4 per cent. A few items on teaching methods were included.

All of the items were of the five-choice type, and final scores were corrected for guessing by subtracting one-fourth of the number of wrong responses from the number of correct responses. A few items taken from the examinations are given below. Those candidates whose total scores fall in the top 27 per cent are designated as the high group (**H**), and those in the bottom 27 per cent as the low group (**L**). The figures in the left-hand columns indicate the per cent of each group marking a particular choice as the answer.

1. Of the following, the most satisfactory material for demonstrating capillary circulation with a micro-projector is the

H	L	
13%	16%	(1) ear of a mouse.
83%	**18%**	(2) **tail of a tadpole.**
0%	18%	(3) finger of a student.
0%	14%	(4) intestine of a frog.
3%	17%	(5) lung of a frog.
1%	17%	*Item omitted.*

2. An important difference between the somatic cells and the mature gametes of the human body is that the

H	L	
3%	8%	(1) chromosome number of the somatic cells is half that of the gametes.
1%	3%	(2) somatic cells lack chromatin while the gametes possess it.
80%	**10%**	(3) **chromosome number of the gametes is half that of the somatic cells.**
0%	3%	(4) somatic cells are larger than the gametes.
8%	36%	(5) genes are present in the gametes but lacking in the somatic cells.
8%	40%	*Item omitted.*

3. Lime is obtained from limestone by

H	L	
1%	1%	(1) soaking it in water.
4%	13%	(2) dissolving it in acid and drying it.
5%	21%	(3) grinding it to a powder.
85%	**51%**	(4) **heating it in a kiln.**
1%	3%	(5) pressing the moisture out of it.
4%	11%	*Item omitted.*

4. In the triangulation method of determining the distance of a nearby star from the earth, the base of the triangle is the diameter of the

H	L	
33%	51%	(1) earth.
1%	3%	(2) moon's orbit.
61%	**23%**	(3) **earth's orbit.**
0%	3%	(4) sun.
0%	4%	(5) galaxy.
5%	16%	*Item omitted.*

5. A lens may be corrected for chromatic aberration by

H	L	
3%	12%	(1) grinding it to secure a rectilinear image.
60%	**15%**	(2) **combining it with a lens of opposite dispersive action.**
5%	14%	(3) overcoming all astigmatism in the lens.
20%	23%	(4) combining a diverging lens with a converging lens of similar refractive index.
0%	6%	(5) moulding it to the proper shape before grinding it.
12%	29%	*Item omitted.*
0%	1%	*Item not reached.*

TABLE II

Distribution of Scores on the examinations in biological and physical sciences.

	Biological Sciences		Physical Sciences	
* Scaled Score	Raw Score	Frequency	Raw Score	Frequency
	**177		**105	
94			62	2
92			59	
90	159	2	55	3
88	155	2	52	3
86	149	1	49	10
84	144	5	45	7
82	139	3	42	9
80	133	9	39	11
78	127	12	36	5
76	121	13	33	8
74	115	18	31	6
72	109	19	28	19
70	103	16	25	26
68	97	19	23	13
66	90	34	20	22
64	84	15	18	19
62	77	25	16	18
60	71	24	14	22
58	64	21	12	13
56	57	12	10	18
54	50	13	8	13
52	43	11	7	11
50	37	14	6	7
48	31	8	4	14
46	25	3	3	5
44	19	1	2	4
42	13	4	1	2
40	9	1	0	2
38	4			
36	0			
	Median = 89	No. = 305	Median = 18	No. = 292

* The value given is the lowest value falling within the particular interval.

** Maximum possible raw score.

Table II shows the distribution of raw scores and their relation to the computed Scaled Scores on both

Continued on Page Twenty-eight

Suggestions for Projects in Science

● **By John M. Roth, M.Ed.,** *(University of Pittsburgh)*
HEAD, SCIENCE DEPARTMENT, CHARTIERS TOWNSHIP HIGH SCHOOL, HOUSTON, PA

Are you a real teacher of science or are you merely doing a day's work? How much of the crusading spirit do you have?

You can't find suitable projects for your science classes? Mr. Roth finds no difficulty. His paper clearly shows that determination and zeal can make up for any lack of time or space or funds. As you read this article you will catch something of the writer's enthusiasm.

Mr. Roth presented this paper in November, 1941, before the Annual Divisional Conference at State Teachers College, California, Pa. He writes that he has a list of several hundred projects in biology that he will permit other teachers to use on request.

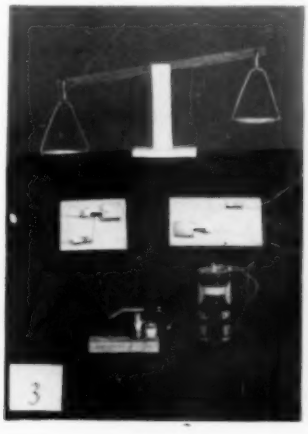
●

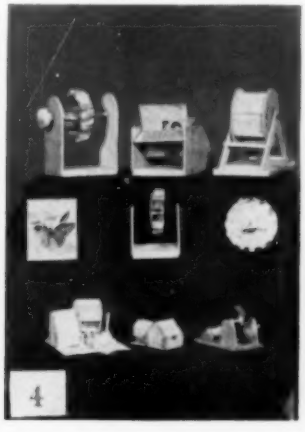
The trend to teaching by means of special projects is one of the more important changes in secondary-school science teaching.

The project method should not be used entirely to replace ordinary class work, as has been done by some teachers, nor should it be limited entirely to demonstration projects, projects carried on by the teacher and merely presented to the students. Students must do things for themselves. The science classroom must be pupil-centered. Projects should be done by the students with but a minimum of supervision and advice by the teacher. They are used to supplement class work. They are not done in class, nor in place of, class work. Projects are always done voluntarily, but they may be teacher inspired.

As science teachers you may be interested in the "A" project idea which some teachers use successfully. Students with an average of B or better are permitted to proceed with a project. Students doing only C work or below have enough to do to keep up with classwork. without attempting anything extra. Many A students are able to do their work with but little effort—superior students are often the most neglected students in our schools—and have lots of time left for mischief. A student must do an "A" project to receive the grade of "A" on his report card. He must do this additional work to earn the high grade. The hard working, interested student with only "B" ability, by doing an "A" project, will be able to earn the grade of "A", which otherwise might be out of his reach.

Beside the grade, motivation may be secured from other sources. Carrying out an interest, the stimulation of successfully accomplishing something worth while, the hope of reward at the Annual Science Fair, and recognition at the school's Open House, are some of the drives that encourage the completion of a project.





RESEARCH PROJECTS

FIGURE 1—*A long term, research type group project. This nutrition experiment received second prize at the Buhl Planetarium Second Annual Science Fair in the Biology Division.*

FIGURE 2—*A short term individual handicraft project. It was made by Raymond Brand, a ninth grade student, to illustrate the principle of the electric motor in the General Science Unit on Electricity.*

FIGURE 3—*Examples of General Science class projects. Balances were made to motivate the unit on Machines. Simple telegraph sets and electric tops were constructed by many of the students during the unit on Electricity. All balances, telegraph sets, and tops had to work well before the student received credit.*

FIGURE 4—*Water wheels of various types made of scrap materials, an example of a Ninth Grade class project. Every student built one as a part of the regular home work during the General Science Unit on Water.*

Even if you do not use the "A" project idea, use projects as teaching aids anyway. It is the concern of the teacher to maintain the group interest of the class. This can be done most effectively by developing a list of projects for the gifted and enthusiastic, as well as for those of lower I. Q. who want them. Advanced students are developed and others are stimulated. Keep your list up to date by constantly adding to it. Have all types of projects for all types of students.

Lists may be prepared for physics, chemistry, and general science. Such a list for biology would include *class* and *individual* projects.

Class projects are special projects to be undertaken by the entire class as a group. For example, each student in my general science class was required to make a water wheel, balance, electric motor, and a telegraph set. Some of these, chosen at random, are here illustrated. Natural history surveys of the local area near the school, in which one group lists the birds, another the insects, another the flowers, etc., are good. Nutrition experiments with one group weighing and measuring the food, others feeding the animals, compiling conclusions, etc., can be done. Or make a miniature stage and plan the setting for different geological ages. Work in groups, and let each group plan only one stage setting and do it well. Work on a school museum, label the trees and landscape the school grounds or gather harmful insects such as bag worms, tent caterpillars, or Japanese beetles.

Individual projects may be carried on by one student or by congenial groups of two or three. This type of project can be separated into two divisions: *short* and *long* term projects; that is, six-week and semester length projects. Each of these divisions should include about five variations for a complete, well-rounded project program: projects for the articulate, the artisan, the artistic, the acquisitive, and the abashed. Remember that every student can be reached if we use the correct approach to his nature. It might be well to study this classification further giving a few illustrative examples.

SHORT TERM PROJECTS

A. **For the Articulate.** This type of extroverted student might enjoy demonstrations, reports, talks, or stories which may be presented before the class, taking flowers to absentees, shut-ins, or children's hospitals, trips and hikes, assembly programs, or such things as helping to celebrate bird day or Arbor day, or in fact anything which will give him a chance to perform before an audience and to receive the acclaim of his fellows.

B. **For the Artisan.** The hand-minded we have always with us. They can do some fine work so give them a chance. Let them make cell models, mount skeletons, make study skins, aquaria, cages, and bird houses. Or try grafting, tree surgery, or making frozen animal sections and mounting them.

C. **For the Artistic.** Take advantage of the artistic ability of some of your students that, perhaps, can be interested in no other way. Have them make posters, lantern slides, cartoons, drawings, and charts for the classroom. Or try photography. They can make many fine illustrations which may be used as teaching aids.

D. **For the Acquisitive.** This is the collector, or human squirrel. Scrapbooks on various topics, bird nest, rock, leaf, flower, gall, insect, spider web, data, weather, or any other type of collection will appeal to him.

E. **For the Abashed.** These are the introverted, shy, research-minded types, disliking the limelight, but doing careful and worthwhile work. Let them work on some problem you just haven't had time to do. This type is attracted to individual projects such as raising fern prothalia, moss protonema, or cultures of protozoa, raising perfume of medicinal plants, herbs, or experimental animals. Reports on books of a biological nature will appeal to them.

LONG TERM PROJECTS

These are similar to the others mentioned above, but require a longer time to complete.

A. **For the Articulate.** Ambitious assembly programs, directing or writing plays with a biological background, or starting a local blood bank are good projects for this go-getter type.

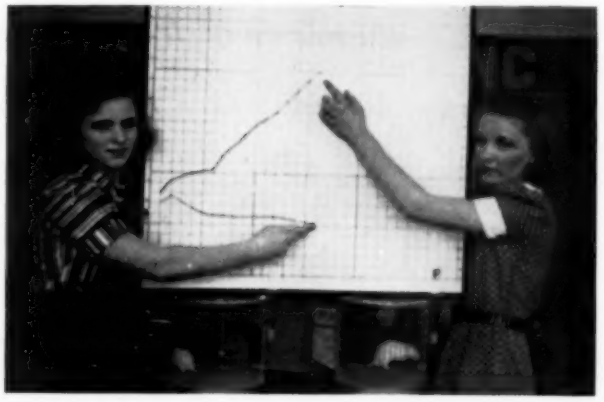
B. **For the Artisan.** Make and use an incubator, build a good habitat group, or puzzle boxes for use in psychological experiments, make shelves, tables, and other equipment for the school museum.

C. **For the Artistic.** Paint the backgrounds of habitat groups; make a classroom mural showing typical examples of each phylum; make models as teaching aids using soap, plasticine, clay, papier-maché, or any other available material.

D. **For the Acquisitive.** Start a herbarium, or continue over a longer period of time the collections mentioned before.

E. **For the Abashed.** Soilless gardens, mutation or hybridizing experiments, trying the effect of colchicine or sulfanilamide on plants, bacteriology, bird-banding, or other long time research type projects will be enjoyed by these good students. It is often surprising how able high school students really are if we give them a chance to do actual research.

Continued on Page Twenty-two



Frances Abacic and Nellie Nagode tabulating the results of a long term nutrition experiment, carried on as an "A" project. It later received second prize in the Biology Division of the Buhl Planetarium Science Fair.

A Sun-and-Earth Model

● **By Lynn Harrington**
SCIENCE DEPARTMENT, CENTRAL SCHOOL, MT. UPTON, N. Y.

This is another helpful how-to-make-it article. Other teachers have experienced the same difficulties that Mr. Harrington encountered in trying to explain to students the rotation and revolution of the earth and the effect of the inclination of the earth's axis. But Mr. Harrington decided to do something about it.

This article tells what he did. Perhaps you will be stimulated to follow his example.

This paper should be read in connection with Professor Thurber's article on Page 11.

●

Teachers of general science and physiography are aware of the difficulties commonly encountered in discussing problems involving the relative positions of the sun and earth. Pictures, blackboard diagrams, and other two-dimensional illustrations used in explaining the effects of the inclination of the earth's axis, rotation, and revolution, often serve to confuse rather than to clarify the issue. The problem, by its very nature, demands a three-dimensional model. The apparatus described here was constructed to meet this need.

Most small schools are plagued by a scarcity of funds for the purchase of teaching supplies. The construction of laboratory apparatus from odds and ends of available material thus offers a real opportunity to the science teacher who would improve the limited supply of demonstrational materials he may have available.

The model shown in the accompanying illustration can be constructed as follows: A sheet of plywood, 30" square by ¼" thick, is used as a base. Upon this is mounted a second piece of plywood, of the same dimensions. The second piece differs from the first in that from it is cut a ½" track in the shape of an ellipse, with axes of 24" and 25". This track represents the orbit of the earth. At the center of the boards is a 3" sink bolt, which is countersunk in the lower board (to prevent scratching of the table upon which the model is placed), and which extends up through the boards. This bolt must be threaded its full length to allow the nut to be run down until it clamps the boards tightly. Upon the upright bolt, a small pipe (about 3/8" in diameter and 4½" long) is placed. The top of this pipe is welded to the center of and at right angles with a small pocket flashlight. On the side of the pipe, near the bottom, a small steel rod (about 1/8" in diameter and 12½" long) is soldered so that it is parallel with the light, and extends out across the track at right angles.

The earth is represented by a soft rubber ball, approximately 2½" in diameter, and preferably white. A hatpin, cut to a length of about 5", penetrates the ball and represents the earth's axis. The ball is supported by a small wooden block, 2½" long, 1½" wide, and 1" thick. In this block are bored two very fine holes, to a depth of ½". One hole is perpendicular to the length of the block, and the other is inclined 23½° to the perpendicular. The pin can be placed in either of these holes, depending upon the problem under discussion when the model is in use.

A third hole, large enough to hold loosely a 1/8" stove bolt is bored through the block from top to bottom near one end. Another block, of the same size, is used to support the block just described. The lower block carries the upright bolt upon which the upper block can be pivoted. The lower block is bored through laterally to carry the rod extending from the pipe at the center of the board. This rod should fit quite loosely in the block. A hole ½" in diameter and ½" deep, is bored into the bottom of the lower block. A small bearing or marble

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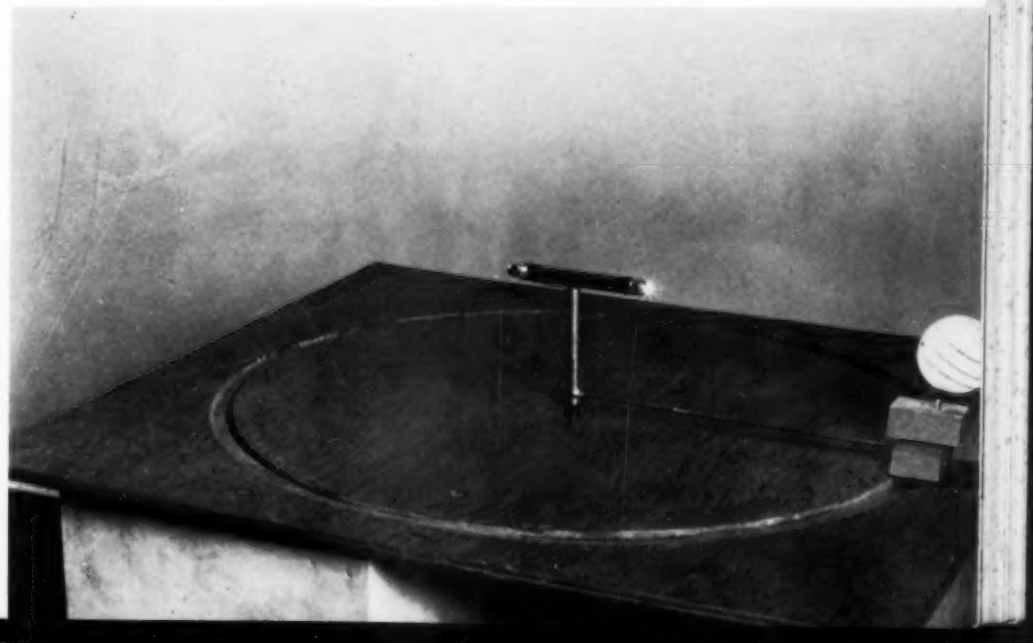

Educational Problems in National Emergencies

● **By Wojciech Swietoslawski, D.Ch.**
MELLON INSTITUTE OF INDUSTRIAL RESEARCH, PITTSBURGH, PA.

A stranger within the gates looks at the American system of education.

Dr. Swietoslawski, who is internationally known as a scientist and educator, was once professor of physical chemistry at the Warsaw Polytechnic Institute, later dean of its department of chemistry, and finally its Rector. From 1935 to 1939 he was Minister of Education of the Republic of Poland. He has published numerous textbooks, and some 300 papers in eight languages.

A political refugee, he has lectured recently at important American universities and is now engaged in research at the Mellon Institute.

●

Problems connected with educating millions of American boys and girls and training them for citizenship are of supreme interest when this nation, like the other nations of the world, faces the most difficult period in its history. In times of great emergency, such as war, the behavior of the whole population is of the utmost importance. Such behavior, without doubt, depends to a large extent upon how the young are trained and mentally conditioned by the teachers in the schools.

Several years ago, when I was responsible for the education of Polish youth, I made a statement before our Parliament, and also before an International Catholic Congress, that I desire to repeat now. The statement is this: "It has been proved during many centuries that religious education is the only base upon which a high standard of national morality can be built."

Most of the teachers to whom this article is addressed teach in schools in which religion is a part of the curriculum. These teachers can, while they teach, inculcate in the minds and hearts of their pupils a feeling for religion and an understanding of the brotherhood of man. That is the background of their whole educational plan. We are convinced that the schools under religious control which prepare the young properly to fulfill the duties of good citizenship constitute a most powerful factor in the development of a nation.

For many years I studied education and its problems in my native country. As a newcomer to America I am naturally interested in similar problems here, and I have tried to obtain a clearer understanding of the American system by comparing the methods of training used in the United States with those prevailing in Europe before the outbreak of the War. You may be interested to know the kind of impression American methods make on a newcomer.

First, I am struck by the fact that through its introduction of the ten-year compulsory system of instruction the United States has developed the largest school system in the world. Here children form a greater percentage of the total population than in most other countries. The number, about 41 per cent, is much higher than in most European countries where the range is only from 30 to 35 per cent. In the United States some 20 per cent of the whole population attend school. Consequently many teachers are needed. Teachers form the largest group of university graduates. In this country every fifth person one meets on the street is a student, and one person in every 150, or even 130, is a teacher.

America's standard of living makes it easy for all to acquire an education. This, together with compulsory schooling, accounts for the fact that here we find students attending high school in greater numbers than elsewhere. It was several years ago that the number of students enrolled in high school per million inhabitants first surpassed that to be found in any other country.

It is difficult to make a similar comparison for college students since there is a considerable difference in the European and American educational systems. Allowances must be made for the fact that the college freshman in America is about two years younger than the freshman in Europe where junior colleges are attached to high schools, not to colleges. But even when the necessary allowances have been made, the number of college students is relatively much higher in the United States than in Europe. All these are encouraging facts leading to the conclusion that in the United States the number of intellectuals per million will soon exceed those in any other country of the whole world. But one must bear in mind that the larger the number of students the greater the responsibilities of the teachers. This is always true. In wartime, however, such responsibilities become greater.

Ordinarily, the enemy attacks in two different ways: by military force, and by insidiously inculcating destructive ideas and spreading them throughout the nation. It is the duty of teachers to equip those under their charge to defend their country against both methods of attack. The young must be psychologically prepared either to become good soldiers themselves or, if necessary, to help the army by manufacturing guns and airplanes and ships. They must be taught to detect foreign propaganda and to have a high resistivity against subversive doctrines that may be spread by

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Catholic Mathematicians of the Sixteenth and Seventeenth Centuries

● **By Genevieve Offer**
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This paper is a brief account of some of the noteworthy mathematicians who lived in a period when important advances were being made in algebra, geometry and trigonometry. The work of these men forms the basis of much of the mathematics that is taught today.

Miss Offer gives intimate glimpses of these men and accounts of their accomplishments that should be of interest and service to teachers of science and mathematics.

●

Like every other science, mathematics was developed through the labors of many individuals of many countries and many ages. Although the first name we connect with mathematics is that of Thales in 600 B. C., the subject was developed to a considerable extent long before his period. At times its progress has been slow; in fact there have been periods when no advancement was made. Yet there are some centuries, particularly the sixteenth and seventeenth, when a great deal of interest was taken in mathematics. Investigation shows that credit for the advances made is due in great measure to the discoveries and work of Catholics. For the development of algebra we must look to Vieta, Cardan, and Tartaglia. The studies of Descartes and Pascal were great steps forward in geometry. Although trigonometry was pretty well developed in the early ages, Cavalieri and Vieta made improvements. These mathematicians and a few others of whom we shall speak, belonged to the Catholic Church. These men, as we shall see from a study of their work, are responsible for much of the subject matter of the mathematics taught in our high schools at present.

Before very much progress could be made in algebra, an improvement in its notation was necessary. Because of the new symbolism he devised, Francois Vieta (1540-1603) is called the father of modern algebra. He received his early training under the Franciscans and later studied law at the University of Poitiers. Through his law practice he came in contact with and was somewhat influenced by the Huguenots, but he died a Catholic. We are concerned here with the improvement he made in algebraic notation. In his *In Artem* he denoted known quantities by consonants and unknown quantities by vowels, and in this way he afforded a concise statement of every problem that was reasoned out. He was very thorough in his treatment of equations, finding out the relation between positive roots and the coefficients, and devising solutions by new methods for equations of the second, third, and fourth degree. In the appendix of *In Artem* he treated the addition and multiplication of algebraic quantities and the powers of a binomial up to the sixth.

Vieta's work in geometry is not so significant, but he did write *Supplementum Geometria* which is a collection of geometrical problems. His contributions to trigonometry consisted of an extension of the table of Rheticus, as well as formulas for the sine and cosine of multiple angles. This survey of Vieta's work is evidence enough of his contribution to the development of mathematics.

At a somewhat later period in France we find the leading scientists, musicians, and mathematicians gathering together at the informal meetings sponsored by Mersenne. Marin Mersenne (1588-1648) was a Minimite friar, a theologian, a philosopher, and a mathematician. His first publications were theological and polemical studies against atheism and scepticism; but later he devoted his time almost exclusively to science, making personal experimental researches, and publishing a number of works on the mathematical sciences. He was interested in the theory of numbers, but his chief contribution to the development of mathematics was the great impetus he gave to the leading scientists of the day. Among the men who attended the meetings he sponsored were Rene Descartes, and Etienne and Blaise Pascal, father and son. When any member of the group had theorems to present, he would have them printed on loose sheets of paper and distributed to the members at the beginning of the meeting. By conducting these meetings Mersenne stimulated interest in mathematics, and the discussion and exchange of ideas brought about considerable advancement in the subject. So to Mersenne a great deal of credit is due. He supplemented his lack of genius in this field by his encouragement and moral support.

Perhaps you know Descartes as a philosopher, or as as physicist, or as a mathematician. It is in the latter capacity that we are concerned with him here. Rene Descartes (1596-1650) studied at the Jesuit College of LaFleche and later at the University of Paris where he formed a lasting friendship with Father Mersenne, who became his adviser. It was Mersenne who brought him back to more serious pursuits when he began to lead a free and dissipated life. The advancement of mathematics, however, was given a great impetus by his genius. In algebra he brought out the distinction between algebraic and transcendental curves. He made use of what is now called "Descartes' rule of signs" by which the possible number of positive and of negative

roots of an equation could be determined from the variations in sign. He is credited with the introduction of the system of indices now in use a^3 or a^4, and he set the fashion for denoting variables by x, y, z and the constants by a, b, c. But Descartes' greatest contribution was the discovery of analytic geometry,—expressing geometry in terms of algebra by means of Cartesian coördinates. This system of coördinates, invented by and named after Descartes, made it possible to describe a geometric curve plotted on perpendicular axes in algebraic symbolism. By using this system, two or more curves could be referred to one and the same set of axes, and the points in which the two curves intersected determined by finding the roots common to their two equations. Analytic geometry is most important for the investigation of conic sections; in fact it has made their study possible. This discovery of Descartes made possible a much greater development of mathematics.

We have referred to Blaise Pascal (1623-1662) as having been present at Mersenne's gatherings. In this man we find a true genius, but, unfortunately, one infected with the very prevalent Jansenism of his day. When he was thirty-one he followed a vision and practiced severe asceticism, spending the rest of his life at Port Royal. It was in his younger days, before he was under these influences, that we find his mathematical genius shining forth. In fact, when he was sixteen years old, he presented an essay on conics at one of Mersenne's conferences. He had made all his progress in geometry without the aid of a teacher. *Essay Pour Les Coniques* was so comprehensive that the other members of the conference at once supposed it to be the work of his father. At nineteen Pascal invented the first adding machine to assist his father in some statistical work. But his work in any of these fields cannot be compared with the genius he displayed in geometry. His was a great contribution to the development and advance of mathematics.

There were Catholic mathematicians in Italy as well as in France who made great progress during the sixteenth and seventeenth centuries. The first of these, Cardan and Tartaglia, are interesting characters. The Church does not deny that in its fold are sinners as well as saints, and Cardan must be classed with the former. One of the most gifted of men of his time, he was physician, astrologer, physicist, mathematician, and philosopher. He was a rather eccentric man, his entire career being a succession of most incoherent acts. A gambler, if not a murderer, he was also a student of science, solving problems which had long baffled scientific investigation. His was the genius that is closely allied to madness.

Cardan's mathematical fame came about through his work in algebra. Before his time algebraists had confined their attention to the positive roots of an equation, but he discussed negative and even complex and imaginary roots. He was acquainted with Descartes' rule of signs even before Descartes' time, and he succeeded in solving correctly certain questions in probability. He stands out in the history of mathematics because of his dispute with Tartaglia concerning the solution of the cubic equation. Before we get into the discussion of this controversy let us find out something about Tartaglia.

Nicola Tartaglia was a tutor of mathematics at Venice. A self-taught man, he had to overcome many obstacles throughout his life. It is from him that we get a good deal of information concerning the commercial customs of the time. He published an arithmetic, *General Tractati di Numeri et Misvre*, which contained a complete account of the business mathematics of the Venetian merchants. But Tartaglia is even more remarkable for his work in algebra. In 1541 he achieved the triumph of solving the cubic equation. The glory of giving these results to the world, however, was not his, because Cardan, having obtained a knowledge of them under a most solemn pledge of secrecy, inserted them with some additions in his *Ars Magna*. He tried to justify himself, somewhat, by acknowledging obligations to Tartaglia. Not only did Cardan succeed in defrauding Tartaglia at the time, but many modern writers have attributed the solution to Cardan, so that Tartaglia has not even the posthumous reputation which, at least, is due him. Regardless of this controversy, we realize that the cubic equation was finally solved in the sixteenth century. This accomplishment was a big step forward in the development of mathematics.

Another Italian, Bonaventure Cavalieri, S.J., (1598-1647) was one of the most influential men of his day. From 1629 until his death he occupied the chair of mathematics as Bologna. He suffered for many years from gout and like Pascal sought relief from pain in his mathematical pursuits. He worked in trigonometry, but his only noteworthy contribution in this study was his symbolism for the trigonometric functions. He denoted sine, cosine, and tangent by the first two letters of each, and their co-functions by the same symbol followed by the number two. We are using a different symbolism today, but his was a considerable advance. Cavalieri is also responsible for making the use of logarithms common in Italy. But his real contribution to the further development of mathematics was his invention of the principle of indivisibles to which he was led by his investigations on the determination of areas and volumes. He assumed that lines were made up of an infinite number of points, surfaces of an infinite number of lines, and solids of an infinite number of surfaces. This was a considerable improvement over the method of exhaustion used by the Greeks. It was, in fact, the forerunner of integral calculus.

Whereas Cavalieri was interested in pure mathematics, his teacher, Galileo, worked in applied mathematics. Because of the observations he was able to make by means of the telescope he constructed, Galileo discarded the old theories of the solar system. Some say he was finally tried for heresy on the charge that he said that the earth moved around the sun. As the

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Using the Scale Model in Teaching Astronomy

● **By Walter A. Thurber**
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Here is a sound and sensible article that teachers of General Science especially should not miss. Although it is not so intended it is in effect a sermon on teaching concretely.

If in the past those who taught our present teachers about the heavens had followed the plan here described, not only the teachers themselves but the pupils they are now instructing would have a much more accurate idea of the solar system.

Models are good but their usefulness may be limited. Scale models may be necessary.

This paper should be read in connection with Mr. Harrington's article on page 7.

●

Astronomy is a big subject, considerably too big for the average classroom.

Naive indeed must be the teacher who considers that charts and diagrams and ineffectual little models can do justice to so grand a subject. Yet we are compelled by circumstances to depend chiefly upon such devices; sentiment demands the inclusion of astronomy in high school science even while failing to provide the night classes that could give the subject so much meaning. Teachers can but make the most of an unhappy situation.

If teachers are to use charts and models, it is essential that both they and the pupils appreciate the limitations of these devices. For obvious reasons, two scales are generally used, one for distance and one for size, with the latter much exaggerated. For instance, in the usual demonstration of an eclipse, two balls held about a foot apart are placed before a light source less than ten feet away. This demonstration is used frequently even in the grades.

The weakness of such a demonstration lies in the fact that teachers may fail to acquaint pupils with the extent of exaggeration. In fact, it would be interesting to know how many teachers themselves know the proper spacing of such objects for correct representation.

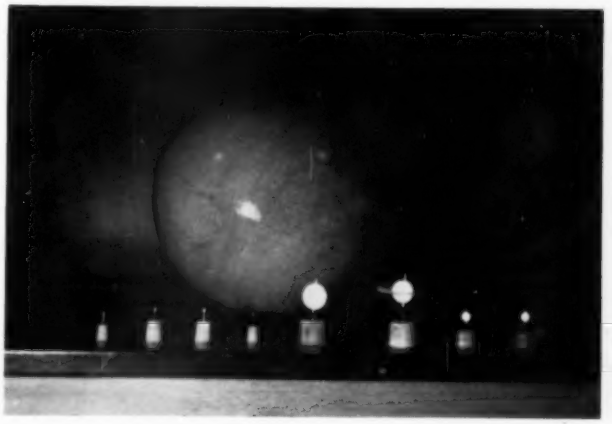

FIGURE 2.
Models of the sun and of the three inner planets placed at proper distances from the sun. Pluto would be more than a mile away; the nearest star more than 8,000 miles.

FIGURE 1.
Scale models of the sun and the planets. Pluto is not included.

Probably the best means of showing the extent of exaggeration is to introduce the reasonably accurate single-scale model first. Such a model, although failing to give adequate concepts of millions of miles, does insure a correct concept of *relative* sizes and distances.

The writer has found that a scale model of the solar system is simple to construct. An old geography globe a foot or eighteen inches in diameter serves as the sun, the impression being heightened by giving it a coat of bright paint. Pinheads, large beads and small balls represent the planets. The diameters of these last may be increased slightly if necessary by dipping them in melted paraffin. It is desirable to attach the planets to large corks or blocks of wood so that they will not be lost in "space."

Such a model does not fit in the classroom; it requires an area the size of a small city. But a football field or other large open space will take care of the

inner planets, and the position of the other planets can be referred to familiar landmarks.

Here is the first lesson, that the sun and the planets are insignificant in the vastness that surrounds them. No amount of talking and no number of charts or books will ever approach in effectiveness actually seeing and realizing that a large pinhead and an eighteen-inch ball, when placed half the length of a football field apart, represent the earth and sun.

There are other immediate lessons, of course. The scale model shows *in three dimensions* the relative sizes of the sun and the planets. It has long been recognized that two-dimensional representation does not give true concepts of three-dimensional objects; yet teachers sometimes rely exclusively upon charts and diagrams for study of the solar system.

When the matter is brought to their attention, pupils realize how little of the sun's heat and light falls upon our earth. They thus develop some faint appreciation of the enormous energy output of the sun.

Also, if pupils calculate the distance to the *nearest* star, which would be some 8,000 miles for the model using the eighteen-inch sun, they begin to appreciate something of the vastness and emptiness of space.

With older and more interested students, the large-scale model can be used to solve some of the simple puzzles of astronomy. The meaning of the zodiac can be demonstrated by using distant objects to represent the constellations along the ecliptic. The difference between solar and sidereal time can be explained and calculated. The appearance of Venus as a morning or an evening star, and the change in its apparent brightness can be explained. Such phenomena as transits and conjunction of planets are made simple to understand.

The writer has found it a valuable exercise to set up the model to represent conditions that actually exist at the time the class meets. Then, after a short study of the model, the pupils are asked to point toward the real, though invisible, planets. For instance, if Venus is the morning star and Jupiter is on the zenith at midnight, the pupils point slightly ahead of the sun for Venus, and on a line from the sun through the earth for Jupiter. This exercise gives a feeling of greater reality to the study of the planets. It also helps to establish a proper sense of direction in the heavens, rather than one based upon models or charts held in a horizontal plane.

A night meeting, particularly if planets are visible, helps immeasurably in giving reality to the study of the model. Pupils learn to recognize the North Star, the Big Dipper, the Little Dipper and Cassiopeia. The constellations of the zodiac can be pointed out to them and the apparent motion of these objects can be described. Later, the pupils can apply their findings to the model.

The writer has had some success with optional night classes, particularly when the use of a small telescope is promised. Some teachers use the additional lure of a "hot dog" roast or a marshmallow toast. Not all pupils come, of course, but the more interested respond.

The writer has had considerable pleasure in working out other problems such as the reason for the rare occurrence of transits of Venus and Mercury, and the reason for the apparent reversal of motion of Mars. He promises that interested teachers will get as much exercise while adjusting the model as in a good game of golf.

Nothing has been said in this paper about studying the galaxies and the spiral nebulae. The writer does not feel qualified to discuss them. He certainly would not recommend the making of a model of the galaxy on,—of all things,—a bicycle wheel, as was done in one sixth grade course of study. The writer believes that there is at present altogether too much stress upon these little-known subjects to the detriment of study of more familiar things. What can be gained by teaching a wealth of uncertainty when there is so much in the immediate environment deserving of attention? ●

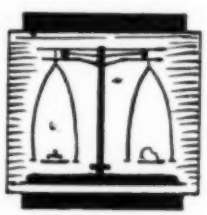

TABLE OF SIZES AND DISTANCES FOR A MODEL OF THE SOLAR SYSTEM

Body	Actual Sizes and Distances		Relative Sizes and Distances	
	Diameter in Miles	Mean Distance from Sun in Miles	Diameter in Inches	Distance from Sun in Feet
Sun	866,000	———	18 in.	—
Mercury	3,030	36,000,000	.063 (1/16)	62
Venus	7,700	67,200,000	.160 (1/6)	116
Earth	7,900	93,000,000	.162 (1/6)	161
Mars	4,230	141,500,000	.088 (1/12)	245
Jupiter	86,500	483,300,000	1.795 (1 3/4)	835
Saturn	73,000	886,000,000	1.517 (1½)	1,530
(rings)	173,000		3.600 (3½)	
Uranus	32,000	1,800,000,000	.665 (2/3)	3,120
Neptune	31,000	2,800,000,000	.645 (2/3)	4,850
Pluto	?	4,000,000,000	—	6,920
Alpha Centurae	—	25,500,000,000,000*	—	8,300 miles
Betelgeuse	240,000,000*		415 feet	

* From the *Encyclopedia Brittannica*, Fourteenth Edition, 1930.

The World of Color
Part III, Color Measurements

● **By Isay A. Balinkin, Ph.D.,** *(University of Cincinnati)*
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The difficulty of describing accurately in words any particular color has long been recognized. When the number of pigments and dyes was small the distinctive names which were applied served satisfactorily. But with the discovery of a multitude of synthetic dyes the situation became highly complicated.

Dr. Balinkin here describes the modern Munsell method of exact color identification. He discusses "hue", "value" and "chroma."

This is the last of a series of three articles on Color. The others, "Light and Color" and "How do we see?" appeared in our September and December, 1941, issues.

●

In our previous discussion on the structure and the method of working of a human eye, we learned that the eye acts as a gateway between the physical stimulus and the visual sensation. The retina, with its network of light receptors converts the physical radiant energy into nerve impulses which follow a rather complicated "telegraphic system" leading to our brain where the visual consciousness of light or color is instigated.

In this talk we will outline briefly various methods used to describe, specify, and measure color. By the term "color" we will mean "the general name for all sensations arising from the activity of the retina of the eye and its attached nervous mechanism," as defined in the report of the Colorimetry Committee of the Optical Society of America in 1922.

When we deal with pigments, paints, dyes, or colored signals, color in itself is the commodity of value. In other instances color serves as an important indicator of quality. This is particularly true in many articles of agriculture both raw materials as well as finished products, such as cotton, wool, silk, various oils, flour, or dairy products. And, finally, color is used for purely aesthetic purposes where it plays an important role in pleasing the prospective buyer. Such objects include practically every article of industry and art: textiles, ceramic tiles, automobiles, furniture, food-stuffs, and colored movies, to mention only a few. New ways are found to use color for our greater comfort, safety, and even health. Quite recently a new term has been coined and we may now speak about various arrangements of color as "Mood Conditioning." Mental suggestions which are frequently associated with color are powerful factors. Can forty million American women adorned with lipstick and rouge be wrong?

The annual trade value output of articles where color is an important consideration runs into billions of dollars. Today, the problem of color specification and control through measurement is of immense importance. Particularly so because there are literally millions of perceptibly different colors which may be available.

There are several ways in which colors may be designated. The simplest way to describe color is, of course, by some name. When the number of available pigments and dyes was small it was a simple matter to specify a color by reference to its origin or use. Take for example such color names as ivory, cream, snow white, chrome yellow, Prussian blue, indigo, amber, and many others. After the discovery of the English chemist, Perkin, in 1856 of a synthetic dye the description of any particular color became a hopeless task.

Let me illustrate this difficulty by quoting the request for a specific color of wall paper that Stevenson, one of the clearest and most forceful writers of English, sends from Samoa to his friend in England: "For a little work-room of my own at the back, I should rather like to see some patterns of unglossy—well, I'll be hanged, if I can describe this red—it's not Turkish and it's not Roman and it's not Indian, but it seems to partake of the two last, and yet it can't be either of them because it ought to be able to go with vermilion." Mark Twain attempts to describe a particular shade of blue in the following words: "It is that sensuous, pervading, ramifying, interpolating, transboreal blue which is the despair of modern art." Just imagine your problem if you had to pick out a color according to these specifications! Even in the sixteenth century the desperate need for color names engaged the word-artist to create: rat-color, widow's joy, or chimney sweep. In the eighteenth century French women wore colors of such extraordinary designations as Rash Tears, Paris Mint, Stifled Sigh and similar inspirations. In our own twentieth century we can hardly be considered outdone with such color names as Basketball, Wireless, Elephant's Breath, Cocktail-green, or Swing-time.

The second method of color specification is the establishment of material color standards in the form of an atlas or color cards. There are some very extensive "color dictionaries" which contain as many as seven thousand different color samples. When intended primarily as an exposition of available colors such arrangement serves a useful purpose. It has, however, certain limitations, among which we may mention:

lack of permanence, difficulty of reproductibility, restriction of range, and lack of uniformity in passing from one color to another.

Among the many attempts to devise a practical system of color classification, the most successful one is certainly that introduced by Munsell in 1905. In order to be able to understand the method of arranging colors in this system we must first of all have a very clear idea of the three attributes or dimensions of color, which were first clearly stated by Helmholz. The best way to present these three attributes of color is to perform a few simple experiments. Let us, therefore, set up a bright incandescent lamp in front of a simple triangular prism and allow a narrow ribbon of light to traverse the glass, and throw a spectrum on a white screen. We can distinguish the prominent colors from violet, on the extrme left, through blue to green then yellow, orange and finally to red at the extreme right. The variation in the appearance of different regions of the spectrum, that property of color which enables us to say that one color is red, another blue or green, is the first and most important attribute of color which Munsell calls *hue*. The same aspect of color was found by physicists to depend upon the wave length of light, and is called by them "dominant wave length."

Let us now isolate one particular range of the spectrum, say green, and find out what variable factors can be introduced to change its appearance. Let us decrease the intensity of the lamp, our light source. The brightness of the green color is now reduced and as the current through the lamp is lessened still more, so is also the brightness of the green patch of the spectrum. This attribute of color surface which determines the relative amount of energy which it reflects is designated by Munsell, as *value*. For neutral grays the variation is from zero for an absolutely black, to 10 for a perfectly white. This aspect of color has received from the physicist such very common names as "brightness" or "lightness."

Finally, as we look on the spectral green color, in the originally dark room, we turn on now just one electric lamp. The green color we saw a few moments ago is not the same green we see now. It has become much weaker. The added white light has diluted the originally strong "chroma" of the spectral green. And *chroma* was the word adopted by Munsell. In scientific parlance this aspect of color is christened "saturation." Spectral colors are one hundred per cent saturated, neutral grays have zero saturation.

These three attributes of color are very conveniently represented by Munsell in the form of a color sphere. The five principal hues are evenly spaced along the equator of the hue circle. The neutral grays, varying in value from absolute black to perfect white, are placed along the central vertical axis of the sphere, with the black at the south pole and white at the north pole. The variation in chroma for any particular hue and value is represented by placing the colors along a horizontal line, close to the axis for those that are only grayish, and farther away from the axis for colors strong in chroma. The unique feature of the Munsell color system is not only its simple notation, such as Red of value 5 and chroma 8, but that Munsell was the first one to realize the importance of arranging and numbering the colors and their attributes in *equal visual steps*. From the practical standpoint of simplicity as well as choice of harmonious combinations for a color balance, the Munsell system found for itself a great number of ardent followers.

The attempt to establish a rational terminology for color specifications based upon an objective method of color measurement is a comparatively new field in physics. Before we can say a few words about such measurements, the meaning of the term "to measure" as it is used by physicists must be clearly stated and emphasized. To measure any physical property means essentially to compare it with a similar property of another object which we agree to call a standard. We must also define a set of physical operations which will allow us to achieve this objective comparison yielding a numerical value. For example, in measuring the length of an object we first of all establish a physical standard of a unit length as the distance between two lines of a certain platinum-iridium bar adopted by an international agreement. Secondly, we devise a method of comparison in which the standard measuring stick is superimposed upon the object to be measured

The necessary standards for color measurements were adopted by the International Committee on Illumination at its meeting in London in 1931. From the physicist's viewpoint, up to that time there existed a procedure which would allow a graphical presentation of spectral reflection characteristics of any given sample. Such a curve gives the relative percentage of visible light energy reflected from a colored sample as compared with reflection from a perfectly white substance. This comparison is performed in an instrument called the spectrophotometer which selects a narrow spectral region and compares the energies reflected in that region for both the sample and the standard. A spectral reflection curve is the fundamental basis for colorimetric specification. Such a curve sepcifies the Substance which is only one of the factors in our visual appreciation of color. The standards concerning the other two factors, Source and Sensation, were established by the International Committee on Illumination. These are known as I. C. I. standards.

To give a sufficiently extensive range for color evaluation under various conditions of illumination, the Committee specified not one but three sources of illumination, known as Illuminants A, B, and C. The color of illuminant A corresponds to a common variety gas-filled tungsten electric lamp, illuminant B gives the light distribution similar to noon sunlight, and illuminant C corresponds to average daylight illumination. The latter source is the one most frequently used for color specifications.

Finally, the data on the sensitivity of the human eye to various regions of the spectrum as determined by

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Practical Suggestions
For the Teaching of Science

● **By George E. F. Brewer, Ph.D.,** *(University of Vienna)*
DEPARTMENT OF CHEMISTRY, ROSARY COLLEGE, RIVER FOREST, ILL.

Teaching "tricks" are a legitimate means of instruction if they accomplish the desired purpose. Every good teacher uses them. Collaboration among teachers in exchanging such methods and devices is greatly to be desired.

Dr. Brewer presents some interesting personal ideas about how to teach science. His discussion is concrete, his point of view refreshing. Perhaps you have not thought of using the examples he cites.

The second part of this paper will appear in our next number.

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PART I

We have every reason to be proud of the results science has achieved in the past, not only regarding its philosophical values but also regarding the close contacts science has gained with the production of industrial merchandise and with the necessities of daily life. The fruits of this evolution, which we all enjoy, make us confident that science is a guarantor for the prosperous future of human kind, and we teachers of science are proud, in educating future scientists, to work so immediately on that development.

In considering the connection between science and the necessities of life, we must realize the grave responsibility that is laid on our shoulders by the fact that we are educating workers who are destined to carry on the development of science. Aware of this responsibility, we cannot too frequently analyze and discuss the situation and the problems we are facing in order to increase our depth of understanding.

During the past twenty years many theories have been advanced concerning the best methods for teaching science. It is now acknowledged that we are teaching neither a subject, nor a book, but that we are teaching the student. Regarding the best way of proceeding, there is no unanimity of opinion. The variety of factors concerned in the teaching of science may make it impossible to find one single method that would bring good results even in all schools of the same type, not to speak of the different types of schools and their special needs. It is also difficult to judge whether the average student of today has a better knowledge or a deeper understanding of science than had the average student of twenty years ago. This is true because we lack a standard of comparison and also because the subjects themselves have undergone important evolution. The fact, however, that teachers have been able to prepare enough students to meet an increased demand for scientifically trained workers, is an indication that our general ways of teaching are keeping pace with the evolution.

From my personal experience I gather that the mental attitude of individual students of science toward special problems is a far more satisfactory one than their mental attitude toward general problems or toward science itself. Too many students are sceptical regarding the reliability of scientific methods, and the percentage of students who doubt that they themselves can rightly observe known phenomena in carrying out an experiment, is still higher. In such cases the difficulties are easily remedied by the teacher. Far more difficult to deal with are pupils who after one year of high school education in a special branch of science, overestimate their acquired knowledge; and certainly the same applies in too many cases to the college graduate in evaluating his own knowledge. An amazingly high percentage of students are wrong regarding the fundamental position of fact and theory. Since in all these cases the mental attitude of the student toward science itself is concerned, the error is a basic one, and it will not be enough to state the right point of view once and only once during a certain course. It is necessary to bring all the various devices of teaching into a system that will finally produce in the student a state of mind that we can call the right attitude toward science.

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From this point of view let us first consider briefly and in a general way one of our greatest problems: the training of specialists.

A comparatively long time ago the body of scientific data was already so large that the schools were forced to divide science into specific branches, and to teach each of these branches in separate courses. Our desire was and is to give our pupils a maximum knowledge of science, but we are faced by the physical impossibility of gaining an absolute knowledge of all branches of science. Thus the nature of the subject itself made the education of specialists a necessity. Later on, as a consequence of the close contact of science with manufacturing, a countless number of industries and institutions made ever increasing demands for scientifically trained staff members. Naturally, these organizations want people trained for their special purposes. Gradually special schools or courses of training had to be established for the express purpose of educating "specialists in a special branch of science."

For all these reasons the education of specialists is necessary, but this does not alter the fact that all branches of science have but one common underlying subject: nature. We divide this subject into special branches wilfully, but such division is in itself irreconcilable with the ultimate purpose of studying nature. The history of science is full of examples proving that most of the achievements in science have been accomplished by the ingenious correlation of ostensibly unrelated facts, as well as by using the specific methods of investigation of one branch of science for the investigation of facts in another branch of science.

As an example, we may recall Galvani's physiological experiments which in his and Volta's hands[1] brought such excellent results in the field of physics. It is not hard to find a number of examples where great scientists acknowledge the fact that their ideas could only have been developed when facts from another field than their special one were brought into consideration. Van't Hoff, for instance, reports: " . . . . . The affinity of sodium sulfate to its water of crystallization corresponds therefore to 3.27 mm. mercury pressure . . . . . Leaving the laboratory with these questions in mind I met my colleague, de Vries, and his wife. He was at that time engaged upon osmotic investigations and he made me acquainted with Pfeffer's determinations. . . . "[2] This quotation speaks for itself. Here a man of profound knowledge found the solution of a problem when he was made acquainted, incidentally, with facts that had been developed in another branch of science.

But even inside of one branch of science we know of cases where evolutions were gravely hindered because the then leading men in that particular branch of science had not directed their minds toward the discovery of the common principle in their subject and were, therefore, not ready to see it. Is not a tragedy hidden in the report that Alexander Reina Newlands (1864) when explaining at a meeting of British scientists the laws he had observed regarding the characteristics of elements when he placed them in a series according to their atomic weights, was ironically asked by the chairman, whether there are similar laws to be observed when the elements are arranged according to the alphabetical order of their initial. This "wisecrack" was born out of a mind aiming at the isolation of individual facts; whereas Newland's observations were the fruit of a broad scientific mind, seeing a common underlying principle, undistracted by a number of ostensibly contradicting facts, but based upon a great number of characteristic features.

The conclusion we may draw from these examples is clear: Faced by the physical impossibility of gaining absolute knowledge of all branches of science, we are compelled to divide and subdivide, but we should do our best to make our pupils realize that the ideal we want to approach as nearly as possible is knowledge in all branches of science and not merely in one of its special fields. One of the easiest ways of transmitting this thought continually during a course of lectures is to choose examples and experiments for demonstration out of the fields of other branches of science.

It would for instance increase understanding if during a course in chemistry, osmotic pressure should be demonstrated by showing the influence of water upon plants.* Having thus introduced the student to the importance of this general phenomenon and having aroused his interest, it should be easy to make him follow Pfeffer's and van't Hoff's ideas.

In teaching the fundamentals of electricity, why shouldn't we repeat Galvani's experiment with the frogs' legs? There are three good reasons to make the student familiar with this experiment:

1. The historical reason, together with the opportunity to demonstrate and, what is more important, to discuss how Galvani approached this fact wrongly in supposing that the electricity originated at the joint of muscle and bone, whereas Volte[3] approached this fact rightly and realized that the current is produced at the junction of the two metals (copper and iron), the frog leg acting only as an "indicator" for the existence of the current.

2. The possibility of widening the horizon of the pupil in demonstrating a physiological experiment during a course in physics or chemistry, thus taking the occasion to refer once more to the indivisibility of science.

3. To give a demonstration of that same muscular contraction that makes the touching of electrical implements so dangerous.

These two examples of experiments suitable for demonstration during lecture, are given to illustrate how examples may be chosen in compliance with the ideas we are developing in this paper.

The definition of specialization, from the teacher's standpoint, as the instruction of pupils in but one branch or field of activity within a general subject, indicates in itself that there is a lack of instruction regarding the other branches of this subject. In order to counterbalance this lack, we must teach how and where to find the knowledge that is lacking: that is the use of a library. Unquestionably, there is a steady increase in the number of scientifically investigated facts, which in turn must steadily increase the gap between the maximum knowledge possible in any scientific area and the knowledge that can possibly be acquired by the pupil. In other words, in comparison to the number of data discovered, the knowledge acquired in school necessarily becomes more and more insufficient, if we are not making the pupil more and more familiar with the use of the library. Finally, anticipating that the evolution of science is going to go on in the future as it did in the past, the most

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* For such an experiment the "Rose-of-Jericho", (resurrection plant), (anastatica hierochuntica, Linn.) may be recommended. [O'Hanlon. *Fundamentals of Plant Science*, p. 145: . . . "This interesting little plant may be kept many years in its dry state; after which, if put into water, it will expand and appear to be alive again." . . .]

Seasonal Devices in the Teaching of Biology

● **By Sister Mary Aelred, O.S.F., B.Ed.,** *(Duquesne University)*
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Why not have a little fun in the schoolroom now and then? It doesn't hurt, especially when learning is stimulated. It is a good thing to change your routine at times.

Here are some original devices that you may care to use occasionally. Students will like them because they are concerned with the game that at the moment probably is one of the students' chief interests.

These aids should be used with caution as the writer carefully points out.

●

Out of the questionable material of which most legends are made, there has grown up, in unscientific circles, a pleasant, yet still legendary, belief that teaching science is a painless experience, entirely free of the stumbling blocks that sometimes make the teaching of other subjects difficult. One sentence should suffice to undermine this attitude; a few more sentences may make our position clearer.

Undoubtedly, the sciences do have a special appeal to students. The opportunity to study the physical things in their environment, the thrill of "making" something themselves, these constitute a real, positive, mind-set toward learning science material. But this interest must be unusually deep to enable a student to grasp and *retain* the many difficult terms and expressions of a scientific vocabulary as they occur in the lesson or experiment. Consequently "drill" and "review" constitute an important and delicate phase of science teaching.

The term "delicate" is used, for drill and review can be so boring and distasteful that their purpose is defeated. Consequently these steps in teaching should be handled with great care. Since interest must be kept at a high pitch all through the year, devices for review and drill which are of a seasonal nature can be used to advantage. Those which are suggested here have worked successfully for a number of years. I have found them to be a satisfactory solution of the problem of providing a thorough review that will hold the pupil's interest while satisfying his desire for individual credit. The set-up described is centered around biology, but it can be applied easily to general science, chemistry, or physics.

The materials needed to use these devices successfully include an interested teacher, an ordinary class, and a "class card" for recording individual achievement. The class card is ruled horizontally to indicate the days of the week and a "Test," and vertically to indicate weeks in the months, with places at the right for tabulating the monthly record. At the bottom are spaces providing for three separate reports and a total, a record of credits, and of credits and percents forfeited. Such a card can be easily modified to suit the ideas of the teacher in charge.

Touchdown!

The device we call "Football" is usually played during the current football season, from the last week in September until Thanksgiving. The class is grouped into teams, evenly matched as to numbers only. Each team selects a captain and an appropriate name. The teacher shuffles the class cards, then asks a question of the student whose card comes up first. If he answers correctly, his credit is marked immediately on his class card. The team score is not recorded until the entire team has answered.

If all the members on one team answer correctly, the team scores a touchdown, and is given six points. Should two members of a team miss questions, the team is given three points, a field goal. If more than two members

FIGURE 1.
On this chart are recorded the individual scores of the players on four teams competing in a Basketball Tournament. Teams are distinguished by using "basketballs" of different colors.

fail to answer satisfactorily, their team does not score. If time permits, we select from the touchdown group any five students and give them another question. Correct answers to these questions entitle the team to one "extra" point, while the individual who answers correctly scores an extra point for each question. The results of the game, that is, the team scores, can be recorded on a chart from week to week. Figure 1 shows the chart we used last year.

FIGURE 2.
On this cardboard chart football scores are recorded.

Football can be used to advantage once a week, on a specified day. For question material we use all the material previously taught. Granting fifty extra credits to each member of the winning team proves a stimulating reward.

Make That Basket!

For review in the study of the invertebrates, for example, the myriapods and the crustaceans where the terms are unfamiliar and difficult, the device of "Basketball" provides a good method of drill. Here the answers are nearly all one-word replies, given to statements such as: appendages found on the abdomen of the crayfish, used to hold the eggs of the female? The answer is "swimmerets."

After the class has been divided into teams, one team really plays the other. The captain's chief duty is to keep individual scores. The first player is given a question. If he answers correctly, his score is registered thus:

	Goal	*Foul*	*Total*
Ralph Gruber.....	2	—	2

Then the first player on the opposing side is given a question. If this player is unable to *answer and spell the term* correctly, the next player on the opposing team is entitled to take up the unanswered or incorrectly answered question. If he answers the term correctly, he is given a credit of one under the heading *Foul*. He still has a chance for his own question, too, and if he answers that correctly, it will count for two points. Then the score for him would appear.

	Goal	*Foul*	*Total*
Robert Obringer....	2	1	3

He earns two points by answering his own question correctly, and an additional point for answering the question missed by the player on the opposing side.

Immediately after a player answers correctly, his captain records his individual score on the blackboard. After the game is over, each individual score is marked on a paper "ball" and placed beside the player's name on a permanent chart which hangs in a prominent place in the room. Such a chart is shown in Figure 2. The total of all individual scores is the team score. Each team has a different opponent. In a class divided into four teams, for example, the winner of the first group of two plays the winner of the other group.

Credit may be marked on the class card by multiplying the individual score by five, because five usually constitutes a convenient unit for a correct answer in the usual class recitation.

We play "Basketball" during the basketball season, from December to February, inclusive.

Three Strikes—You're Out!

To conduct a lively review in a unit on human biology, we recommend the game of "Baseball." Divide the class into teams, nine players on each team, and elect captains. The teacher acts as umpire. Now turn the classroom into a baseball diamond, with chairs representing the bases. Line up the teams on either side of the room. The first player on Team A goes to bat, that is, he selects a question from a box at the home plate. If he answers the question correctly, he goes to first base. The next player on Team A then comes to bat. If this player also answers satisfactorily, he goes to first base while player No. 1 walks to second. If player No. 2 misses his question, player No. 1 remains on first, and one "out" is called on Team A. As each player reaches home plate, he scores a run for his team. Each team gets the usual three "outs"; then the next team comes to bat.

Individual credit may be given by recording each hit, multiplied by five, made by an individual player. Among the questions in the box may be placed some especially difficult ones marked "three-bagger" to challenge superior students. This type of question entitles the player who draws it to walk three bases and send home all the players on base.

All these games allow for individual improvement. For example, in basketball some students may want to carry out a system of credit for personal fouls and for technical fouls.

Teachers are cautioned against placing too much emphasis on the technical side of the game, and "making

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Applied Geology

● **By Timothy C. May, Ph.D.,** *(Catholic University)*
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This is the third and last of a series of articles by Dr. May on various phases of geology. The others have appeared in recent issues.

In the present paper the practical applications of the science are considered. Ores, building materials, fertilizers, fuels and gems receive attention. The metallurgy of a few metals is described. A brief discussion of some of the engineering applications of geology is included.

Teachers of chemistry and general science will find in this paper considerable valuable teaching material.

●

The changes which the earth's crust may undergo have been discussed in earlier articles. It remains only to consider some of the more practical phases of geology in order to complete our resumé of the science. To do this, a few words must be said of those simple geologic entities of which the surface of the earth is composed; namely, minerals and rocks.

Minerals can best be defined as "naturally occurring inorganic substances having definite chemical composition and characteristic physical properties." They obey all the laws of true chemical substances, and can be assigned definite chemical formulae. Often they crystallize into forms of great beauty. The orderly arrangement of the molecules which gives them their external geometric forms, gives them internal arrangement as well.

Minerals may be classified into several rather interesting diagnostic groups among which are found the simple, elementary substances such as native gold, diamond, and elementary sulfur; and a legion of chemical compounds including sulfides, carbonates, oxides, silicates, vanadates, and the like. Physical properties in minerals include form, color, hardness, luster, diaphaneity, cleavage, and fracture. Color and crystalline form are the two characteristics most commonly applied in sight identification of minerals. In a word, minerals have a definite "personality" by which they disclose their identity to those who study them.

The larger lithic units are called rocks. Rocks form large masses of relatively uniform material. They may be said to possess an average uniformity but, when viewed closely, are usually found to consist of a mixture of several minerals. Rocks are classified into several groups: igneous, sedimentary, and metamorphic.

Igneous rocks are derived from molten rock solutions and include highly crystallized mixtures such as granites, and less clearly defined volcanically derived substances such as natural glasses, ash, and pumice. Sedimentary rocks are types that have resulted from the consolidation of sediments derived from the weathering of pre-existing rock masses. They include sandstones, shales, limestones, and residues of various kinds. Both these types may be so deeply buried that they become highly contorted and chemically modified by the pressure to which they have been exposed, in which case they are called metamorphic rocks. To this class belong the slates, marbles, gneisses, and schists. Thus, the history of a rock is disclosed by its chemical constituency and its physical structure.

The practical benefit derived from a study of minerals and rocks is the ability to recognize and to learn how to utilize mineral wealth. Everything we use, even the food that preserves in us the spark of life, comes from the earth. Mineral resources may be classified into two groups; the metallic and the non-metallic. The former consists of those compounds from which metals can be extracted; the latter group are those that may be used as compounds or mixtures of compounds in the various industrial arts. Mineral resources may be more specifically classified as ores, building materials, gem stones, fluxes, abrasives, and the like. In order to get some idea of the utilitarian value of mineral wealth, let us consider some of the types.

Building materials involve such substances as stone, clay, lime, and cement. Under the heading of building stone, we note such rocks as granites, sandstones, slate, and marbles. Granites are extensively used because of their resistance to weathering, their compressive strength, and beauty. Granites occur in a multitude of colors which take a beautiful polish. They consist of fairly coarse textured igneous rocks which can be employed to produce very pleasing effects. Sandstones also have been used extensively as building stones because of their ease of quarrying. The effects that they produce are very pleasing but in temperate climates their use has been limited because of their porosity. Water is apt to soak into their pores and freeze, thereby causing the rock to peel and rupture.

Slate is largely used for roofing purposes, and in the manufacture of switch panels because of its great dielectric strength. Marble is one of the most decorative building stones employed in the building industry. Owing to its relative solubility it is used for interior decoration more than for external construction. Limestone, which occurs in various colors, is also used extensively as a building stone. Vermont, Tennessee, and Georgia lead in the American field as producers of marble. The New England states lead in the production of granites, while much of the sandstone has been

produced in the Connecticut Valley and in New Jersey. The outstanding limestones come from Indiana, which furnishes the bulk of the limestone used in the East.

Sulfur and pyrite are used most extensively in the manufacture of sulfuric acid which is probably the most important of the so-called heavy chemicals. Up to the beginning of the present century most of the sulfur produced came from Sicily. Later, while drilling for oil, large deposits of this valuable mineral were found to be imprisoned beneath quicksands in Louisiana and Texas. Owing to the peculiar mode of occurrence this sulfur could not be extracted by ordinary mining methods. Herman Frasch, an engineer, solved the problem by the use of super-heated steam. By this method the sulfur was melted beneath the surface and pumped out in a relatively pure state. The market was suddenly flooded with cheap sulfur and the Sicilian producers thought they were the victims of some "Yankee ruse." They reacted by forcing down the market price of sulfur. Unhappily, they turned out to be the victims of their own methods, for producers in this country could make a profit on a price that cut seriously into the Sicilian margin of profit. Thus a sort of *laissez faire* agreement was entered into by the two producers on opposite sides of the Atlantic. At the present moment Japan is also a big producer of sulfur.

Sulfuric acid can also be manufactured from the burning of iron pyrite or "fool's gold." A cupriferous pyrite has been mined for a long time at Ducktown, Tennessee, for the copper it contained. Originally the sulfur dioxide, evolved during the smelting of this ore, was allowed to escape in the air. As a result, the vegetation in the vicinity was destroyed and the farmers were "up in arms" against the metallurgists. Legislation was passed to prevent the metallurgists from allowing the noxious sulfurous fumes to escape. As a result of the new laws the metallurgists were driven to utilize the sulfur dioxide to manufacture by-product sulfuric acid. This ultimately proved a blessing in disguise, for the money accruing from the sale of the acid permitted the metallurgists to use a lower grade of ore than had been possible in the past.

The subject of fertilizers, so intimately involved in the problem of agriculture, is also a problem of geology. Plants require three essential types of minerally derived food: potash, nitrates, and phosphates. The question of artificial fertilization did not arise in feudal times owing to the fact that the agricultural products were utilized locally and the waste materials were returned to the soil to furnish food for the new crop. In modern society, the food products grown in one area are shipped away to be used in another. Thus, the soil becomes weakened of its natural fertility and we must resort to manufactured fertilizers.

Previous to the World War, Germany controlled the potash market because of the great wealth of natural potash occurring at Stassfurt. Since that time the United States has located extensive deposits of potash in western Texas and New Mexico, thus stabilizing its future agricultural resources.

Natural nitrates at the present time are controlled by Chile. So acute has been the demand for nitrates at times that various nations have evolved artificial methods of nitrate manufacture. The Norwegians have perfected a hydroelectric method of nitrogen fixation while the Germans have employed the Haber process. The Muscle Shoals Project of the United States was evolved primarily to alleviate the nitrate problems. In respect to phosphates the United States is singularly blessed. In the dim geologic past large quantities of phosphatic shells and the bones of vertebrates have been aggregated into extensive deposits in Florida, South Carolina, and Idaho.

The gem industry is designed more to gratify man's vanity than to add to his comfort. Among the foremost representatives of the gem industry are the diamond, the ruby, and the emerald. Diamonds are the hardest substance known and, owing to their extremely high index of refraction, are capable of great color play. Diamond is a polymorphous form of the element carbon and yields the same products of combustion as does graphite. The ruby is a form of aluminum oxide that is greatly prized; it ranks next to the diamond in the scale of hardness in the mineral world. Emerald is a form of beryl, a silicate of beryllium. Opals, which are forms of common silica, are prized because of their wonderful play of colors. And so we might go on: turquoise, pyrope, hyacinth, kunzite, all natural minerals made in the great laboratory of nature.

The fuels have great utilitarian value. Natural fuels, largely confined to coal and petroleum, are used to keep the fires of industry burning, and to maintain our bodies at a healthy temperature during the cold winter months. In this way they have contributed greatly to the progress of civilization. Coal and oil are geological bequests from the dim past of the earth's history. The anthracites that abound in eastern Pennsylvania and the bituminous coals that are found in various sections of the country are the products of partially decomposed organic vegetation that flourished in the past. The organic matter that it took millions of years to accumulate will soon be exhausted at the rate of present utilization. Petroleum is probably being consumed at a still more alarming rate. When these fail what will man resort to?

The metallic resources of a nation depend upon the ore mined in that country. An ore is a mineral or aggregation of minerals from which a metal may be extracted at a profit. As the skill of the metallurgist increases, poorer and poorer grade ores may be utilized.

The process by which the metal is evolved from the ore is called smelting. Although the design of the furnace may vary, as may also some of the steps involved, all smelting processes are essentially continuous high temperature processes wherein the material is added in the solid state and tapped off in the molten state. The ordinary procedure is to admix the fuel, usually coke, with the ore and the proper amount of fluxing material, and to ignite the mass. The slag or stony

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NEW BOOKS

Photograph by Robert Turiff Hance

Workbook for Physical Education

• *By* MAE IDDINS, Carson-Newman College. The C. V. Mosby Co., St. Louis. 1941. 144 pp. $1.50.

A mimeograph-type, paper bound, consumable workbook containing brief statements of the rules for some fifty or more sports for women students. In some cases theories, etiquette, faulty habits, and skills needed are indicated. Review questions are included in a number of chapters.

The book is intended for use by students enrolled in physical education courses in schools or colleges, by those planning to become directors of physical education programs, and by recreational directors. *H.C.M.*

It Works Like This

• *By* CAPTAIN BURR LEYSON. E. P. Dutton & Co., Inc., New York City. 1942. 224 pp. $2.50.

Every boy in your school with a mechanical bent, and almost any girl as well who is curious to know how things work, will be entranced by this book. It is written especially for them and in their language. Teachers and parents will like it too.

The explanations of how the airplane, the Diesel engine, the electric generator, the radio vacuum tube and the marine radio beam, television, the mechanical refrigerator and a dozen other modern inventions work could not be given more clearly nor more concisely. Basic principles are explained. The illustrations, photographs and diagrams, really illustrate. The book is worth more than it costs. Better put it on your purchase list. *H.C.M.*

The Machinery of the Body

• *By* A. J. CARLSON AND V. JOHNSON. The University of Chicago Press, Chicago, Ill. Revised Edition. 1941. pp. 620. $4.00.

An elementary textbook for the college student and lay reader written by teachers and investigators whose outstanding accomplishments in the field of physiology need no comment. The book is a "precipitate of years of experience with the attempt to teach human physiology to college students at the University of Chicago". It is clearly written, well edited and copiously illustrated. Whenever it is possible the material is presented so as to be intelligible to one who has no previous knowledge of physics, chemistry or biology. The authors have completely revised the first edition and have added new material on reproduction, alcohol, tobacco and the viruses. A feature of the text which the beginner will find valuable is the frequent references to the experiments and the re-checked observations on which our knowledge of physiology is founded. This method of approach avoids the implication of an unwarranted degree of certainty on the one hand and a "mere recording of facts and controversial theories" on the other.

This book, one of the best of its kind the reviewer knows, is outstanding in format as well as in subject matter. *E.V.*

Working With the Microscope

• *By* JULIAN D. CORRINGTON, Ph.D., Professor of Biology, Washington College, Chestertown, Maryland. Whittlesey House, McGraw-Hill Book Co., Inc., New York. 1941. pp. 418. $3.50.

There has been no satisfactory book published in America dealing, for the intelligent hobbyist, with the numerous techniques necessary for the proper use of the microscope. Interest in microscopic work seems to be making its bid to rival the enthusiasms shown by the amateurs in radio and photography. Dr. Corrington's book leads the beginner through micrology from start to finish in a manner easy to follow for those who have no other instructor. At the same time *Working With the Microscope* will prove a very adequate laboratory guide in college courses or in the high schools where such information is needed to guide extracurricular clubs. *R.T.H.*

Effective Living

• *By* C. E. TURNER AND ELIZABETH MCHOSE, C. V. Mosby Co., St. Louis, Missouri. 1941. pp. 432. $1.90.

A textbook written for students on the high school level. Its purpose: "to help youth discover ways of effective living." Effective living "implies the development of optimum capacity, as an individual, as a successfully adjusted member of a family group, and as a useful citizen in the community." The book deals essentially with problems pertaining to the intelligent maintenance of physical and mental health, and "one's general culture and interpretation of life."

The subject matter, which is ample in amount, is arranged in unit form and presented in easily comprehensible terms. The sequence of the units may be varied to suit special conditions. A self-checking list at the end of each unit "offers an opportunity for the student to determine his progress toward becoming a well-rounded, self-directing individual." References are included for developing each unit further if desired. There is a glossary of technical terms at the end. An appendix lists the most common communicable diseases, arranged alphabetically, giving information as to nature, transmission, incubation period, and methods of control. There are 164 illustrations.

This book should be examined when a change of texts is being considered. *E.V.*

Catholic Mathematicians

Continued from Page Ten

story goes, he recanted to save his life, but modified this recantation by murmuring, "It moves just the same." But according to Whewell, who was a Protestant, Galileo was punished for obstinate contumacy, not for heresy, because he trifled with the authority to which he professed to submit. Although he is remembered mostly for this controversy with the Church, we are concerned here only with his genius in other scientific lines. He was fascinated with the study of mathematics from the first time he came in contact with it. Though he taught the subject at the Universities of Padua and Pisa, he is noted for his work in the application of mathematics to the science of physics. He did remarkable work in statics. In hydrostatics he propounded the more elementary theorems on pressure and floating bodies. It was his fame in this work that secured for him the mathematical chair at Pisa.

Our brief investigation has shown the extensive development which took place during the sixteenth and seventeenth centuries. The credit for this is due in no small measure to certain French and Italian mathematicians. These men—Mersenne, Descartes, Vieta, Pascal, Galileo, Cavalieri, Cardan, and Tartaglia—all were Catholics, some more outstanding in the practice of their faith than others. These men deserve credit for a good portion of the subject matter of the algebra, geometry, trigonometry and commercial mathematics that is taught in our high schools today. ●

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Suggestions for Projects

Continued from Page Six

Try projects. Any teacher can find willing students. *What is necessary is more willing teachers!*

My students are of the average I. Q. We have no money and but little equipment. The students are brought by bus, so we have no time after school. We have no clubs or time set aside for projects in or out of school, but at the present time we are working on the effect of sulfanilamide on geraniums, photography with a micro-projector, bacteriology in the home, the effect of vitamin A on health, raising medicinal plants to avoid importing them, and a habitat group showing how to plant a living snow-fence.

Try projects! Use them to show the correlation between subjects. The boy who won the first prize in the engineering division at the Science Fair last year got the idea and theory in science class, made the project in shop, and wrote up a report of what he did for the school paper in his English class.

TRY PROJECTS ! ! Anyone can find time to do them. Children love them. Projects feed their egos and make them feel important. It is a wonderful privilege to cause the metamorphosis of a problem child into a perfect child by the use of a well-selected project. May it often happen in **your** science classes! ●

Seasonal Devices

Continued from Page Eighteen

the game the thing," instead of "making science the thing," thus detracting from the real purpose of the devices. Teachers should not fail to oblige the student to spell each term correctly. Such a requirement is very necessary.

The teacher of science will, of course, fit these various types of review to the ability of his class. Each device is flexible and can be used at the teacher's discretion. Students find their reviews are always "in season," and almost in spite of themselves they develop a lively interest in review procedures. ●

★ ★ ★ ★

The *Peabody Journal of Education* for November, 1941, contains an excellent list of books compiled by Dr. Hanor A. Webb and entitled "The High School Science Library for 1941." A brief statement accompanies each title. Various selections are suggested to accommodate book budgets of all sizes.

A Sun-and-Earth Model

Continued from Page Seven

fits into this hole, to facilitate movement of the block around the orbit.

The model can be demonstrated most effectively in a darkened room before a small group. By turning on the flashlight and turning the pipe, it is a simple matter to see which portion of the earth is in shadow under any of the conditions which exist during the various seasons of the year. Rotation of the hatpin gives the effect of night and day. If the model is operated with the pin in the vertical hole, the significance of the inclination of the earth's axis can be clearly brought home. It is necessary that the two blocks be used in order that one can be pivoted upon the other so as to maintain inclination in a constant direction. By the use of a small ball, suspended by a string and manipulated by hand, it is quite simple to demonstrate such phenomena as eclipses (both solar and lunar), and phases of the moon.

It is generally possible to build such a model as this in the school shop, but a lack of shop facilities need prove no bar to its construction. It so happens that the original model, described here, was conceived on the spur of the moment by the writer while visiting in a town far removed from his school and shop. The plywood was purchased at a lumber yard where an employee, obviously harboring grave doubts concerning the writer's sanity, was persuaded to hold two pencils to serve as the foci for the construction of the ellipse on one of the boards, and subsequently to cut out the track on the company's jig saw.

A major difficulty was encountered in the soldering and welding of the flashlight and steel rod to the iron pipe. An unsuspecting garage service man was induced to perform the task. As he worked, he was subjected to a brief but intensive lecture on the effects of rotation, revolution, and inclination. His initial disdain turned to genuine interest as he came to understand the purpose of the model, and when he had finished the model he refused to accept any pay for his work.

The question of what to use as the earth's axis was rather a vexing one until an elderly lady in a dry-goods store suggested (and donated) a hatpin. In all, the model was assembled at a total cost of approximately $2.00. It is possible, of course, to vary the content and structure of the model to utilize available equipment. ●

★ ★ ★ ★

Hugh C. Muldoon of Duquesne University was elected first vice president of the American Science Teachers Association at the recent meeting of the American Association for the Advancement of Science in Dallas, Texas.

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Applied Geology

Continued from Page Twenty

material evolved during the process is tapped off at one level and the metal at another. It will be noted, therefore, that cheap coal, suitable for the preparation of good coke, is quite as important to the success of the process as cheap ore.

Though many metals enter into our daily routine, we shall confine our attention to iron, copper, and the more precious metals, gold and silver.

Iron, or rather steel, which is the blanket title applied to the more common alloys of iron, is the principal metal employed in the fabrication of our implements, buildings and vehicles of transportation. It is smelted from such iron ores as hematite, magnetite, and limonite. This country is particularly well provided with iron ore, boasting some of the largest iron deposits in the world. Besides this, the United States leads all other countries in the production of the high grade coals that are necessary to the success of smelting processes. Iron has proven one of our nation's greatest assets.

Copper occurs in two principal types of ores. The native copper ore of Michigan was for a long time the electrical standard of the world. This great deposit is almost unique in its mode of occurrence and in its great extent. The other leading class is of the sulfide type and involves such minerals as chalcopyrite, bornite, chalcocite, and the like. The Rocky Mountain district is exceedingly well provided with ores of this kind. The smelting of copper differs somewhat from that of iron. Instead of smelting directly to the metal, a concentrated cupriferous sulfide known as "matte" is first formed, and this is subsequently converted to the metallic state in a huge refractory-lined apparatus called a "converter." The crude metal thus evolved is purified by electrolysis and subsequently appears on the market in the form of electrical apparatus and such alloys as brass, bronze, monel metal, and the like. Copper is a more costly metal than iron but it finds wide economic usage and its manufacture and fabrication add materially to the comfort and wealth of man.

Gold, silver, and platinum are classified among the more precious metals. The two former are used extensively in the manufacture of coins and jewelry, while platinum is used mostly in jewelry and the arts. Gold is of much more universal occurrence than people believe. The United States possesses a goodly amount of wealth in the form of gold, although it is not so well off as a producer of silver. As a producer of platinum our country is hopelessly in the background.

Let us now consider some of the engineering applications of geology. These can be roughly subclassified into three groups: (1) mining problems; (2) the control of natural waterways; (3) the utilization and development of water power resources. The first concerns itself with the creation of cheap and safe methods of removing ores and other deposits from the earth; the other two are more or less closely related, and are concerned with cheap water power, safe transportaton and the ability to prepare in advance for the future requirements of an ever growing humanity.

Mining is the "go-between" industry that links together the earth and man. Divine Providence gave us a well provided earth to supply our wants, but we must work if we are to enjoy the manifold benefits. The miner removes the ore, the metallurgist smelts and fabricates it, and the populace at large enjoys it in its many forms. However, let us go back to the toiling miner who first sets the ball in motion. Quarrying, or open-cut methods, are not nearly as hazardous as shaft methods, so we shall pass over these with few remarks. Most building stones are quarried, as well as some ores. However, the greater part of the ores are removed by subsurface tunnelling. Men working in the mines must be protected from the dangers of collapsing, and must be assured of proper conditions of ventilation. The former is provided by extensive timbering of the passageways; the latter by the construction of adequate air-ways and the operation of pumps. Coal mines must take added precautions to prevent the hazard of fire. Mother Earth yields us many things, yet not without a struggle.

The engineering control and improvement of natural waterways is a type of work that can be carried out in the light of day, but not without a great deal of physical and mental effort on the part of man. Dams are

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constructed to impound large quantities of water to be used for the development of power, for drinking, or for purposes of irrigation. These enginering structures must be constructed upon nature's foundations and from past experience we have learned that it is wise to consult a geologist concerning the choice of a dam site. By the water impounded behind dams, deserts have been converted into garden spots, and electricity and other comforts have been brought into our lives. Harbors, too, must be continually cared for and improved. We think of New York harbor as one of the greatest natural harbors in the world. It is, but even it requires care. Ambrose Channel, the main ship approach lane, must be continuously dredged. Harbors are continuously charted and the dangerous places marked by spars or light-buoys.

Let us consider the subject of water-power. You have already been told that the sun evaporates moisture from the oceans and large lakes only to drop it upon the slopes of mountains, whence it follows a precipitous course to the valleys below. Often waterfalls are formed which, aside from their great beauty, afford man great possibilities of waterpower. Niagara Falls is an excellent example. Vast hydroelectric power plants have been evolved from conditions of this type and many things have been made available to man that were not dreamed of a century ago. Water power has been called "white coal" because, as it beats itself

Continued on Page Thirty-two

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Educational Problems

Continued from Page Eight

secret agents in such a way as to conceal their foreign origin.

Democracy connotes entire freedom of speech, even the right to express publicly ideas that are directed against democracy or the country itself. Such freedom of expression is based on the assumption that destructive ideas will not be accepted by a great majority of the people. This will always be true if the resistance of the citizens is high enough. Especially in wartime increased efforts must be made to make sure that all citizens shall have an adequate understanding of their duties. They must be warned of the peril that exists when they do not appreciate the possible destructiveness of pernicious foreign propaganda. Here is patriotic work for teachers.

In considering the necessity for teachers to prepare those they teach to protect their country, two tragic events in the history of France should be recalled. In 1870, when France was defeated by Prussia, the Prussians maintained, with Bismark, that the Franco-Prussian war was won by the German elementary school teachers. In our own day, public opinion in France will soon recognize that French school teachers are responsible to a great extent for the collapse of their country in 1940. During the period of two world wars there was no attempt by French teachers to prepare their charges psychologically for national defense. Nor was this true of France alone. The public in many European countries failed to give adequate consideration to the fact that the totalitarian countries had introduced radical changes in their school systems, especially in their training for citizenship, in order to condition their new generation for an aggressive war. The British Prime Minister, Winston Churchill, mentioned this in his historical address to the Congress last December. Everyone knows it to be true. No counter-action against the totalitarian school changes appeared in any democratic country in spite of the fact that immediate action was called for. How well we know it now, after the war has begun! Recent events in Europe demonstrate that such lack of psychological preparation for a defensive war is one of the most powerful negative factors operating against the interests of the Allies.

Let us return, however, to Hitler's preparation for war, a typical example of how plans for aggression must be made. Hitler and his military advisers developed a new strategy and a new tactic. They regulated the whole German industry, with war the single purpose in view. They succeeded in isolating the whole population against the influence of foreign ideas. Hitler used thousands of teachers to instruct the young generation how to help him realize his aims of seizing military supremacy and of creating a German hegemony throughout the world. Systematically these teachers inculcated in the minds of the young Germans

that they were to become world rulers and that all other peoples were to be subordinated and enslaved.

The United States cannot afford to repeat the errors committed by the other democratic countries. Not only the youth but all the people must learn what this country must do to fight and to win this war. The schools can do much. The whole nation is united and it is not difficult to create in the minds and hearts of the young an ardent patriotic enthusiasm and to give them an ideological background for the sacrifices they may be called upon to make in order to preserve their freedoms.

It is easy to understand that the psychological preparation and the feelings of the youth in non-aggressive democratic nations will differ from those that are common in the totalitarian countries. Unfortunately, as yet, few attempts have been made to formulate the bases upon which the right kind of citizenship training should be founded. Most educators agree, however, that the duties of a patriotic citizen in a democratic country can well be learned by observing the historical role of the nation and by examining the foundations of its foreign policy. Citizens who know and understand the ideas that have influenced the country's leaders through the years will appreciate better the background of the nation's collaboration with other non-aggressive countries.

America's program has been based upon peaceful collaboration. In the past it may have seemed superfluous to study and to teach ways of defending and preserving this country. For many years the Monroe Doctrine has been accepted as the basis of the foreign policy of the nation. It was believed, mistakenly, that the two oceans formed natural Maginot Lines which could protect the United States against foreign encroachment. But during the past two decades, and especially during the present World War, the situation has changed. The nation now faces new problems. From the Pacific shores one can see enemy submarines sinking American ships. An air attack may be expected at any time. No longer can the United States stand alone even with all of South America as its friend. Without close cooperation with the other countries that have a like ideological background for their foreign policies the United States cannot exert its proper world influence. It cannot even be protected in its own peaceful development. It is clear that the Monroe Doctrine must be modified and extended.

America could not keep out of any world war originated and conducted by brutal military dictators fighting against democracy. *The United States must fight not only for its own freedom but for the freedom of other nations as well.* These words state clearly the

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historic role that the United States has now accepted by a recent unanimous vote of the Congress. When this vote was taken a new era in the history of the country was begun. This historic event now must form part of the new background for the education and citizenship-training of young Americans.

It is the task of teachers to examine all these facts carefully, and to try to discover the best method of explaining to the young why the fight for the freedom of other nations has been made a new basis for the foreign policy of this nation and why this change received the unanimous approval of the Congress and of the citizens of the United States.

But when the freedom of nations and the security of the United States have been reestablished, the teachers will face another important problem. Having the largest school system and the greatest intellectual and material resources in the world, they should attempt to create in this country the largest center in the world where brotherly love, morality, and Christianity in general will be developed to such an extent that a new and better type of men and women will evolve.

I express the hope that this great task will be fulfilled through the painstaking, hard, everyday work of America's teachers. ●

The World of Color

Continued from Page Fourteen

various workers were intercompared, and one set of data chosen as the luminosity curve for a normal I. C. I. observer.

With these three data at hand the problem of determining the tristimulus values for any reflection curve is simply that of mathematical transformations. The final result yields three numerical values dominant wave length, brightness, and saturation. These three numbers completely specify the color of an object as it appears to a standard observer under the specified conditions of illumination. Color specification in these terms becomes a common language upheld by international standing and understood in every country of the world. ●

★ ★ ★ ★

Dr. Luther S. H. Gable, consultant at the Radium Research Laboratories, Salt Lake City, Utah, addressed the general session of the Catholic Science Teachers Association on December 27, 1941, at the Holy Family Academy, Chicago. His topic was "The Astounding Story of Radium."

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Performance of Teachers

Continued from Page Four

examinations. It will be noted that the raw scores on the physical science examination are considerably lower than those on the biological science test. This may be due in part to the greater diversity of training within the physical sciences. A candidate with satisfactory knowledge of physics but little knowledge of chemistry, geology, meteorology, or astronomy would not tend to make a high score. For science teachers who are called upon to teach various combinations of physics, chemistry, and general science, the need for a balanced background of training in several of the physical sciences seems apparent. The range in performance is very wide on both examinations. On the biological sciences test, the range in raw scores is from 9 to 159; on the physical sciences test, it is from 0 to 62.

Most of the candidates took two optional examinations. As it might be of interest to see (1) what other subject-matter fields were selected by those who took the biological or physical science examination, and (2) to what degree the selection of certain options correlates with performance on the science examinations, Tables III and IV are presented.

The options frequently chosen in combination with the biological sciences were the physical sciences, social studies, mathematics, and English language and literature. With the physical sciences, however, a preponderance (86%) of the candidates selected either biology or mathematics. Languages were the choice of less than 2 per cent of the group taking the examinations in the sciences.

As would be expected, the average performance on a test when taken as the first option was better than when selected as the second choice. The best performance on both physical and biological sciences was made by candidates whose second option was the other science. In general, then, the figures indicate that candidates who have been trained in both the biological and the physical sciences are somewhat better prepared in each of them than are those whose major fields are more diverse. ●

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TABLE III

Mean Scaled Scores on the Biological Sciences Examination of Candidates Selecting Various Other Options.

Alternate Option	Biological Sciences as Option I		Biological Sciences as Option II		Total	
	No.	Mean Scaled Score*	No.	Mean Scaled Score*	No.	Mean Scaled Score*
Physical Sciences	65	70	48	65	113	68
Social Studies	29	65	22	54	51	60
Mathematics	15	68	23	62	38	64
English Language and Literature	18	62	16	61	34	62
Other Options	4	71	13	64	17	66
No Alternate Option	45	66	--	--	45	66
Totals and means for all combinations	176	66	122	62	298	65

*On Biological Sciences.

TABLE IV

Mean Scaled Scores on the Physical Sciences Examination of Candidates Selecting Various Other Options.

Alternate Option	Physical Sciences as Option I		Physical Sciences as Option II		Total	
	No.	Mean Scaled Score*	No.	Mean Scaled Score*	No.	Mean Scaled Score*
Mathematics	44	72	90	61	134	65
Biological Sciences	48	72	65	63	113	67
Social Studies	8	65	7	62	15	63
English Langunge and Literature	6	70	5	60	11	66
Other Options	4	75	3	52	7	65
No Alternate Option	7	66	1	56	8	64
Totals and means for all Combinations	117	71	171	62	288	66

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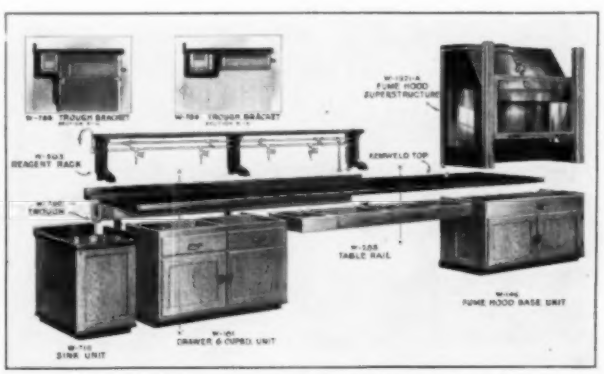
★ ★ ★ ★

There has been some popular objection to the use of the names "nicotinic acid" and "nicotinamide" for the pellagra-preventing vitamin, because of the suggestion of nicotine. The names *niacin* and *niacin amide* have now been officially adopted for these compounds.



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Practical Suggestions

Continued from Page Sixteen

convincing reason for the importance of library instruction may be derived from the fact that we are teaching today, and the pupil is supposed to use his knowledge at some future date, when surely new facts will be known.

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What are the best ways of making the pupil use the library?

First, and above all, the example given by the teacher himself. Quotations, for instance, can be communicated to the class by actually reading or translating them by handing around the volume.

Second, the pupil himself should be given assignments that make the use of the library "natural", rather than a chore to be avoided if possible. It seems advisable, especially when beginners are to be introduced to the use of the library, to connect the laboratory work with the assignments, because the findings can then be used immediately for practical work.

An example will illustrate the point. One of the first experiments a class of beginners in chemistry (college freshmen) had to carry out, was to heat different crystallized substances and to note whether a liquid (water) condenses on the wall of the test tube. The next experiment was to heat a weighed portion of copper sulfate crystals in a crucible and to determine the loss in weight. The class was introduced to the terms "evidence", "indication" and "lack of information" and the following question was put:

Are we now, after having carried out these experiments, in possession of evidence, or of indication, or is there lack of information regarding the following points:

1. That the copper sulfate crystals undergo some change when heated.
2. That the loss is due to evaporation of water.
3. That all the loss in weight is due to evaporation of water?

The factual foundation for the answers was to be stated. The answers were handed in and the problem discussed. Finally, it was concluded that the liquid which condenses would have to be analyzed and if it were found to be like water in all its properties, we would have evidence that it is water; furthermore, if we could "collect" all the water that evaporates out of the crystals and its weight should be equal to the loss in weight by the crystals, we would have evidence regarding point 3. Three of the students were then asked to find out in the library whether there is a method known for the determination of water of crystallization that would give us the desired evidence regarding point 3. At the beginning of the next period one of them gave a five minute oral report about his findings and the experiment was then carried out.

The problems we have mentioned have their root in the ever increasing amount of scientific data that forces us to educate specialists. The training of specialists is a necessity, but the student can be given an awareness of the disadvantages of specialization, and much can be done to train the pupil to find the knowledge he lacks.

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What is the best way to teach specialized scientific material without the all-too-frequent lack of depth of understanding, and without the danger of turning out narrow-minded, unscientific experts who will lose sight of the major implications of the research in their narrow fields?

First, let us introduce the student to the truly scientific approach,—that is to find that point of view which allows us to correlate the facts under investigation to other facts. The pupil has to be taught how to arrive at this point of view by means of demonstrations and experimental work. Then the common features of the facts under investigation have to be stated in the form of a generalization. The so-called laws of nature are themselves generalizations. Many of these laws are even so general that they are approximations. These laws are one of our goals. Out of the demonstrations and the experimental work done, the conclusion, in the form of a law, has to be drawn finally in a precise, usually mathematical, form. It is especially here that the beginner encounters the greatest difficulties.

From my own experience I gather that every young person is interested in science. Could it be otherwise in a world where all our homes are fitted with implements created by the application of science to the necessities of life? Nevertheless, many students avoid physics and chemistry. Can it be our own fault? Is it, perhaps, because our methods of teaching have not found that immediate contact with the problems of daily life, that contact which science itself has found? Do our methods of teaching science ask for too much memorizing of mathematical equations on the part of the pupil? Should we search for, and use, methods which place the experiment above all, a system which makes the pupil remember the wisely chosen experiment and prepares him to draw, by himself, the conclusion in the form of the so-called law whenever that is necessary? Are we, instead, too often asking the student to *give back* memorized laws to the teacher during examinations, laws which in the mind of the pupil are remote from their factual foundation and their practical use? If we choose problems of the right kind—problems and experiments which not only utilize existing student interest, but experiments which actively create and direct interest,—then, surely, comparatively little memorization is necessary.

Our experiments and problems should be chosen so that they serve our purpose:

They should be in direct connection with the daily life.

They should be chosen so that no theory is necessary for their explanation. On the contrary, the theory itself should be deduced from the findings.

The problems should be chosen so that the scientific way of looking at our surroundings does not end for the pupil as soon as the class bell rings.

The problems and experiments should make the pupil actively co-operate during the period of instruction.

The problems and experiments should be part of a system where the teacher not only teaches, but makes the pupil *learn* in the best sense of the word, not merely memorize.

Some examples may illustrate this:

In a high school physics class the chapter on optics was to be begun. Without any preliminaries three pupils of average ability were told to find the angle at which the rear vision mirror of a car has to be placed in order to give the driver the best view of the street behind the car. They were asked to make an oral report at the beginning of the next period and it was casually mentioned that a schematic drawing of the situation, showing the various angles, would be necessary in order to transmit their findings to the class. Their report was discussed and finally the law of reflection was concluded from it.

An example out of the field of chemistry:

The fundamentals of electrochemistry had been covered in a class of beginners in chemistry, to the point when the electric storage battery was to be studied. Before starting with this chapter the class was asked how it can be determined whether the storage battery of a car, even though working satisfactorily, is fully charged or not. The answer had to be written immediately into their laboratory record book and was to be handed in. Then they were asked to find the right answer before the next period. The ground for the study of the electric storage battery was thus prepared, and without tedious and useless memorization one fact was thoroughly established: the formation of sulfuric acid in the cell. It is needless to point out how much easier it is to bear the other data in mind by "association of ideas."

An example of a question, put for the purpose of arousing interest and teaching "scientific approach", follows.

During a lecture period in chemistry, a dry battery and several pieces of moistened litmus paper were passed around, in order to give each pupil the opportunity to see the alkaline reaction at the negative terminal. The class was familiar with the electrolytic decomposition of water as well as with the fact that metal oxides (bases) turn litmus blue; but they had not yet learned about Davy's isolation of the alkali

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metals. Slips of paper were then distributed and each student was told to outline the procedure that might lead to an explanation or to give an explanation if he could think of one.

The answers were just as fantastic, though not as far-fetched, as the explanations offered by well known scientists at the time before Sir Humphrey Davy's experiments were generally acknowledged.[4] The discussion of the answers proved useful in demonstrating to the students, that they have to base their ideas upon already acquired knowledge; e.g., to conclude: bases turn litmus blue; therefore a base should be present, and it is the nature of this base that should be investigated. Secondly, the pupils were effectively taught, that is without memorization, how to determine the negative terminal (and vice-versa) and the deposition of metals at this terminal. An actual quotation from the above cited papers[4] was used to bring up for discussion the problems of the purification of water on one side, and the growth of plants, "chemical gardening", etc., on the other. ●

(TO BE CONTINUED)

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Applied Geology

Continued from Page Twenty-five

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